

**A 3D EDUCATIONAL MOBILE APPLICATION FOR FEMORAL SHAFT
FRACTURES**

**BY
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for the degree of
BACHELOR OF INFORMATION SYSTEMS (HONOURS) INFORMATION SYSTEMS
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UNIVERSITI TUNKU ABDUL RAHMAN

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ABSTRACT

The aim of this project is to develop a 3D educational mobile application to help high school students and anyone without a medical background to understand the human femur bone and its potential shaft fracture. The application provides interactive and immersive visualisations of the femur bone, common types of fractures, and their corresponding treatment options. The application is designed to be user-friendly and accessible to everyone, providing a comprehensive and engaging educational resource. The project utilised technologies such as Blender to create the 3D models, Unity to develop the application and Firebase for the backend infrastructure. The application was tested and evaluated by a group of users without a medical background, who provided valuable feedback to enhance the user experience. Overall, this project provides a novel approach to the educational field and has the potential to increase the awareness of femoral shaft fractures among non-medical professionals, promoting a better understanding of human anatomy and injuries.

TABLE OF CONTENTS

TITLE PAGE	I
REPORT STATUS DECLARATION FORM	II
FYP THESIS SUBMISSION FORM	III
DECLARATION OF ORIGINALITY	IV
ACKNOWLEDGEMENTS	V
ABSTRACT	VI
TABLE OF CONTENTS	VII
LIST OF FIGURES	X
LIST OF TABLES	XVII
LIST OF ABBREVIATIONS	XIX
CHAPTER 1 INTRODUCTION	1
1.1 Background	1
1.2 Problem Statement and Motivation	10
1.3 Objectives	12
1.4 Project Scope and Direction.....	12
1.5 Contributions.....	13
1.6 Report Organization.....	14
CHAPTER 2 LITERATURE REVIEW	15
2.1 Review of the Technologies.....	15
2.1.1 Firmware/OS.....	15
2.1.2 Database	16
2.1.3 Programming Language.....	19
2.1.4 Summary of the Technology Review	21
2.2 Review of the Existing Systems/Applications	22
2.2.1 Anatomyka Skeleton (Source: Anatomyka, 2021)	22
2.2.2 Essential Skeleton 4 (Source: 3D4Medical, 2014)	24
2.2.3 Complete Anatomy 2022 (Source: 3D4Medical, 2021)	26
2.2.4 Summary of the Existing Systems and Proposed System.....	28
2.2.5 Effects of using Mobile Application for Medical Education.....	30
CHAPTER 3 SYSTEM METHODOLOGY/APPROACH	32

3.1 System Methodology	32
3.2 System Requirement	33
3.2.1 Hardware.....	33
3.2.2 Technologies Involved.....	34
3.3 User Requirements.....	35
3.3.1 Functional Requirement.....	35
3.3.2 Non-Functional Requirement.....	35
3.4 Project Timeline.....	36
3.4.1 Project I Timeline	36
3.4.2 Project II Timeline	37
CHAPTER 4 SYSTEM DESIGN	38
4.1 System Design Diagram	38
4.1.1 Flowchart	38
4.1.2 System Architecture Diagram.....	40
4.1.3 Database Architecture Diagram.....	42
4.1.4 Entity Relationship Diagram.....	43
4.1.5 Use Case Diagram and Description	44
4.1.6 Activity Diagram	45
CHAPTER 5 SYSTEM IMPLEMENTATION	54
5.1 Software Setup.....	54
5.1.1 Unity Installation	54
5.1.2 Visual Studio 2022 Installation.....	57
5.1.3 Blender Installation.....	58
5.2 Setting and Configuration.....	59
5.2.1 Linkage between Software.....	59
5.2.2 Device Simulator Setup	61
5.2.3 PlayerPrefs Setup	63
5.2.4 Firebase Setup.....	64
5.3 System Operation (with Screenshot)	70
5.3.1 Splash Screen and Sign In.....	70
5.3.2 Sign Up	72
5.3.3 Profile.....	73

5.3.4 Intact Femur Bone.....	74
5.3.5 Fractured Bone on Femoral Shaft.....	77
5.3.6 General Information.....	81
5.3.7 Video.....	82
5.3.8 Quiz.....	83
5.4 Implementation Issues and Challenges.....	85
CHAPTER 6 SYSTEM EVALUATION AND DISCUSSION	86
6.1 System Testing and Performance Metrics	86
6.2 Testing Setup and Result	86
6.2.1 Testing Setup	86
6.2.2 Result	88
6.3 Objectives Evaluation	132
6.4 Concluding Remark	134
CHAPTER 7 CONCLUSION AND RECOMMENDATION.....	135
7.1 Conclusion	135
7.2 Recommendation	136
REFERENCES.....	138
APPENDIX.....	146
WEEKLY LOG.....	148
POSTER.....	154
PLAGIARISM CHECK RESULT.....	155
FYP2 CHECKLIST.....	157

LIST OF FIGURES

Figure Number	Title	Page
Figure 1.1-1	Stages of Osteoporosis.	2
Figure 1.1-2	Classification of Femoral Shaft Fractures.	2
Figure 1.1-3	Types of Femoral Shaft Fractures.	2
Figure 1.1-4	Fracture Category.	3
Figure 1.1-5	Type 0 of Winqvist & Hansen Classification.	4
Figure 1.1-6	Type I of Winqvist & Hansen Classification.	4
Figure 1.1-7	Type II of Winqvist & Hansen Classification.	4
Figure 1.1-8	Type III of Winqvist & Hansen Classification.	5
Figure 1.1-9	Type IV of Winqvist & Hansen Classification.	5
Figure 1.1-10	AO/OTA Type 32A.	5
Figure 1.1-11	AO/OTA Type 32B.	5
Figure 1.1-12	AO/OTA Type 32C.	5
Figure 1.1-13	Type I of Gustilo Anderson Classification.	6
Figure 1.1-14	Type II of Gustilo Anderson Classification.	6
Figure 1.1-15	Type IIIA of Gustilo Anderson Classification.	6
Figure 1.1-16	Type IIIB of Gustilo Anderson Classification.	6
Figure 1.1-17	Type IIIC of Gustilo Anderson Classification.	6
Figure 1.1-18	Transverse fracture(a).	7
Figure 1.1-19	Transverse fracture(b).	7
Figure 1.1-20	Transverse fracture(c).	7
Figure 1.1-21	Displaced short oblique fracture.	7
Figure 1.1-22	Long oblique fracture.	7
Figure 1.1-23	Oblique fracture.	8
Figure 1.1-24	Spiral fracture(a).	8
Figure 1.1-25	Spiral fracture(b).	8
Figure 1.1-26	Comminuted fracture(a).	8
Figure 1.1-27	Comminuted fracture(b).	8
Figure 2.2.1-1	Anatomyka Skeleton Home.	22

Figure 2.2.1-2	Anatomyka Skeleton Learning.	22
Figure 2.2.1-3	Anatomyka Skeleton Color.	23
Figure 2.2.2a	Essential Skeleton 4 Home.	24
Figure 2.2.2-2	Essential Skeleton 4 Learning.	24
Figure 2.2.2-3	Essential Skeleton 4 Learning 2.	24
Figure 2.2.2-4	Essential Skeleton 4 Quiz.	24
Figure 2.2.3-1	Complete Anatomy 3D Atlas.	26
Figure 2.2.3-2	Complete Anatomy CT Scan.	26
Figure 2.2.3-3	Complete Anatomy Videos.	26
Figure 2.2.3-4	Complete Anatomy Lectures.	26
Figure 2.2.3-5	Complete Anatomy Skeleton.	26
Figure 2.2.3-6	Complete Anatomy Learning.	26
Figure 2.2.3-7	Complete Anatomy Modeling.	27
Figure 3.1	Methodology of Proposed System.	32
Figure 3.4.1-1	Timeline - Project I (Part 1).	36
Figure 3.4.1-2	Timeline - Project I (Part 2).	36
Figure 3.4.2	Timeline - Project II.	37
Figure 4.1.1-1	Flowchart - Part 1.	38
Figure 4.1.1-2	Flowchart - Part 2.	39
Figure 4.1.2	Architecture Diagram.	40
Figure 4.1.3	Database Architecture Diagram	42
Figure 4.1.4	Entity Relationship Diagram.	43
Figure 4.1.5	Use Case Diagram.	44
Figure 4.1.6.1	Activity Diagram - Intact Femur Bone.	45
Figure 4.1.6.2	Activity Diagram - Fracture Femur Bone.	46
Figure 4.1.6.3-1	Activity Diagram - Quiz (Part 1).	47
Figure 4.1.6.3-2	Activity Diagram - Quiz (Part 2).	48
Figure 4.1.6.4	Activity Diagram - Account Registration.	49
Figure 4.1.6.5	Activity Diagram - Login.	50
Figure 4.1.6.6	Activity Diagram - Forgot Password.	51
Figure 4.1.6.7	Activity Diagram - Profile Modification.	52
Figure 4.1.6.8	Activity Diagram - Video Playing.	53

Figure 5.1.1-1	Download UnityHub.	54
Figure 5.1.1-2	Agree with the License.	54
Figure 5.1.1-3	Install UnityHub.	54
Figure 5.1.1-4	Select Editor Version to be Installed.	55
Figure 5.1.1-5	Select Module to be Installed.	55
Figure 5.1.1-6	Select Manage Licenses.	55
Figure 5.1.1-7	Sign In.	56
Figure 5.1.1-8	Add New License.	56
Figure 5.1.1-9	Activate Free Personal License.	56
Figure 5.1.2-1	Download Visual Studio Community 2022.	57
Figure 5.1.2-2	Select Continue and Agree with the License Terms.	57
Figure 5.1.2-3	Choose the Workloads to be Installed.	57
Figure 5.1.3-1	Download Blender.	58
Figure 5.1.3-2	Click “Next”.	58
Figure 5.1.3-3	Agree with the License Term.	58
Figure 5.1.3-4	Browse Location for Blender Installation.	59
Figure 5.1.3-5	Install Blender.	59
Figure 5.2.1-1	Relationship among the Software.	59
Figure 5.2.1-2	Linkage between Visual Studio and Unity.	60
Figure 5.2.1-3	Export models from Blender to Unity.	61
Figure 5.2.2-1	Installation of Device Simulator.	62
Figure 5.2.2-2	Simulator Option Appeared.	62
Figure 5.2.3-1	Search and Install PlayerPrefs Editor.	63
Figure 5.2.3-2	PlayerPrefs Editor Window.	64
Figure 5.2.4-1	Create A New Firebase Project.	65
Figure 5.2.4-2	Name the Firebase Project.	65
Figure 5.2.4-3	Uncheck Google Analytics and Create Project.	66
Figure 5.2.4-4	Create Unity App.	66
Figure 5.2.4-5	Get Package Name from Unity Project.	67
Figure 5.2.4-6	Register App with the Same Package Name.	67
Figure 5.2.4-7	Download Config File and Put under Assets Folder of Unity Project.	68

Figure 5.2.4-8	Download Firebase SDK and Import to Unity Project.	68
Figure 5.2.4-9	Create Script to Initialise Firebase.	69
Figure 5.2.4-10	Firebase Initialised Successfully.	69
Figure 5.3.1-1	Splash Screen.	70
Figure 5.3.1-2	Sign In Page.	70
Figure 5.3.1-3	Sign In Successfully (1).	70
Figure 5.3.1-4	Sign In Successfully (2).	70
Figure 5.3.2-1	Sign Up Page.	72
Figure 5.3.2-2	Sign Up Successfully.	72
Figure 5.3.3-1	Profile Page.	73
Figure 5.3.3-2	Change Username Page.	73
Figure 5.3.3-3	Change Email Page.	73
Figure 5.3.3-4	Change Password Page.	73
Figure 5.3.4-1	Intact Femur Bone - Page.	74
Figure 5.3.4-2	Intact Femur Bone - Labelling.	74
Figure 5.3.4-3	Intact Femur Bone - Rotation.	74
Figure 5.3.4-4	Intact Femur Bone - Scaling.	75
Figure 5.3.4-5	Cut Effect.	75
Figure 5.3.4-6	Inner Part - Page.	75
Figure 5.3.4-7	Labelling Inner Part.	75
Figure 5.3.4-8	Inner Part - Rotation.	75
Figure 5.3.4-9	Inner Part - Scaling.	75
Figure 5.3.4-10	Intact Femur Bone - Info and Notes.	76
Figure 5.3.4-11	Inner Part - Info and Notes.	76
Figure 5.3.5.1-1	Oblique Fracture - Page.	77
Figure 5.3.5.1-2	Oblique Fracture - Rotation.	77
Figure 5.3.5.1-3	Oblique Fracture - Scaling.	77
Figure 5.3.5.1-4	Oblique Fracture - Info and Notes.	77
Figure 5.3.5.2-1	Transverse Fracture - Page.	78
Figure 5.3.5.2-2	Transverse Fracture - Rotation.	78
Figure 5.3.5.2-3	Transverse Fracture - Scaling.	78
Figure 5.3.5.2-4	Transverse Fracture - Info and Notes.	78

Figure 5.3.5.3-1	Spiral Fracture - Page.	79
Figure 5.3.5.3-2	Spiral Fracture - Rotation.	79
Figure 5.3.5.3-3	Spiral Fracture - Scaling.	79
Figure 5.3.5.3-4	Spiral Fracture - Info and Notes.	79
Figure 5.3.5.4-1	Comminuted Fracture - Page.	80
Figure 5.3.5.4-2	Comminuted Fracture - Rotation.	80
Figure 5.3.5.4-3	Comminuted Fracture - Scaling.	80
Figure 5.3.5.4-4	Comminuted Fracture - Info and Notes.	80
Figure 5.3.6	General Information.	81
Figure 5.3.7-1	Video Lists - Types & Classification.	82
Figure 5.3.7-2	Video Lists - Complication.	82
Figure 5.3.7-3	Video Lists - Treatment.	82
Figure 5.3.8-1	Quiz - Start.	83
Figure 5.3.8-2	Quiz - Questions.	83
Figure 5.3.8-3	Quiz - Explanation.	83
Figure 5.3.8-4	Quiz - Answer Wrong.	83
Figure 5.3.8-5	Quiz - Answer Correct.	83
Figure 5.3.8-6	Quiz - Final Result.	83
Figure 5.3.8-7	Quiz – Leaderboard.	84
Figure 6.2.1.1	Physical Device Setup.	87
Figure 6.2.2.1-T1(1)	Empty Email (Test Case 1).	91
Figure 6.2.2.1-T1(2)	Empty Username (Test Case 1).	91
Figure 6.2.2.1-T1(3)	Empty Password (Test Case 1).	91
Figure 6.2.2.1-T1(4)	Invalid Email 1 (Test Case 2).	91
Figure 6.2.2.1-T1(5)	Invalid Email 2 (Test Case 2).	91
Figure 6.2.2.1-T1(6)	Invalid Email 3 (Test Case 2).	91
Figure 6.2.2.1-T1(7)	Different Password (Test Case 3).	92
Figure 6.2.2.1-T1(8)	Invalid Password 1 (Test Case 4).	92
Figure 6.2.2.1-T1(9)	Invalid Password 2 (Test Case 4).	92
Figure 6.2.2.1-T1(10)	Invalid Password 3 (Test Case 4).	92
Figure 6.2.2.1-T1(11)	Valid Inputs (Test Case 5).	92
Figure 6.2.2.1-T1(12)	Sign Up Successful (Test Case 5).	92

Figure 6.2.2.1-T1(13)	Sign Up with Same Email (Test Case 6).	93
Figure 6.2.2.1-T2(1)	Empty Email (Test Case 1).	95
Figure 6.2.2.1-T2(2)	Empty Password (Test Case 1).	95
Figure 6.2.2.1-T2(3)	Account Not Exists (Test Case 2).	95
Figure 6.2.2.1-T2(4)	Wrong Password (Test Case 3).	95
Figure 6.2.2.1-T2(5)	Input with Correct Information (Test Case 4).	95
Figure 6.2.2.1-T2(6)	Sign In Successful (Test Case 4).	95
Figure 6.2.2.1-T3(1)	Empty Email (Test Case 1).	97
Figure 6.2.2.1-T3(2)	Invalid Email (Test Case 2).	97
Figure 6.2.2.1-T3(3)	Account Not Exists (Test Case 3).	97
Figure 6.2.2.1-T3(4)	Submit Successful (Test Case 4).	97
Figure 6.2.2.1-T3(5)	Reset Password Email Received (Test Case 4).	98
Figure 6.2.2.1-T3(6)	Reset Password (Test Case 4).	98
Figure 6.2.2.1-T3(7)	Reset Password Successful (Test Case 4).	98
Figure 6.2.2.1-T4(1)	Empty Username (Test Case 1).	100
Figure 6.2.2.1-T4(2)	Same Username (Test Case 2).	100
Figure 6.2.2.1-T4(3)	New Username (Test Case 3).	100
Figure 6.2.2.1-T5(1)	Empty All (Test Case 1).	103
Figure 6.2.2.1-T5(2)	Empty Password Fields (Test Case 1).	103
Figure 6.2.2.1-T5(3)	Password Mismatch (Test Case 2).	103
Figure 6.2.2.1-T5(4)	Invalid Password (Test Case 3).	104
Figure 6.2.2.1-T5(5)	Incorrect Current Password (Test Case 4).	104
Figure 6.2.2.1-T5(6)	Password Update Successful (Test Case 5).	104
Figure 6.2.2.1-T6(1)	Invalid Email (Test Case 1).	106
Figure 6.2.2.1-T6(2)	Same Email (Test Case 2).	106
Figure 6.2.2.1-T6(3)	Occupied Email (Test Case 3).	106
Figure 6.2.2.1-T6(4)	Empty Password (Test Case 4).	107
Figure 6.2.2.1-T6(5)	Email Update Successful (Test Case 5).	107
Figure 6.2.2.1-T6(6)	Notification Email Received (Test Case 5).	107
Figure 6.2.2.2-T1(1)	Code - Upload Notes to Firebase.	108
Figure 6.2.2.2-T1(2)	Results - Uploading Notes to Firebase Cloud.	108
Figure 6.2.2.2-T2(1)	Code - Retrieve Realtime Data from Firebase Cloud.	110

Figure 6.2.2.2-T2(2)	Results - Retrieving Realtime Data.	110
Figure 6.2.2.2-T3(1)	Relationship between Swipe Direction and Bone Model Rotation Direction.	114
Figure 6.2.2.2-T3(2)	Bone Cutting.	115
Figure 6.2.2.3-T2(1)	Code - Retrieve Score and Display Leaderboard from Firebase Cloud.	118
Figure 6.2.2.3-T2(2)	Results - Retrieving Score and Displaying Leaderboard.	119
Figure 6.2.2.5-1	Offline Test - Data Saved Previously in the Cloud.	123
Figure 6.2.2.5-2	Offline Test - Data Modified without the Internet.	124
Figure 6.2.2.5-3	Offline Test - Data Updated with the Internet.	124
Figure 6.2.2.7-1	Survey Testing - Q1	126
Figure 6.2.2.7-2	Survey Testing - Q2	127
Figure 6.2.2.7-3	Survey Testing - Q3	127
Figure 6.2.2.7-4	Survey Testing - Q4	128
Figure 6.2.2.7-5	Survey Testing - Q5	128
Figure 6.2.2.7-6	Survey Testing - Q6	129
Figure 6.2.2.7-7	Survey Testing - Q7	129
Figure 6.2.2.7-8	Survey Testing - Q8	130
Figure 6.2.2.7-9	Survey Testing - Q9	131

LIST OF TABLES

Table Number	Title	Page
Table 1.1-1	T score of osteopenia, osteoporosis and normal bone.	1
Table 1.1-2	Winquist & Hansen Classification.	4
Table 1.1-3	AO/OTA Classification.	5
Table 1.1-4	Gustilo Anderson Classification.	6
Table 1.1-5	Most common types of femoral shaft fracture.	7
Table 2.1.1	Comparison between Android and iOS Development.	15
Table 2.1.2-1	Comparison of Local Storage and Cloud Storage.	17
Table 2.1.2-2	Description and Characteristics of Databases.	18
Table 2.1.3	Description and Characteristics of Programming Languages.	20
Table 2.2.4	Comparison between the reviewed systems and proposed system.	28
Table 3.2.1	Specifications of Laptop.	33
Table 3.2.2	Tools and Software.	34
Table 6.2.2.1-T1	Unit Testing - Sign Up.	88
Table 6.2.2.1-T2	Unit Testing - Sign In.	93
Table 6.2.2.1-T3	Unit Testing - Reset Password.	96
Table 6.2.2.1-T4	Unit Testing - Update Username.	99
Table 6.2.2.1-T5	Unit Testing - Update Password.	100
Table 6.2.2.1-T6	Unit Testing - Update Email.	104
Table 6.2.2.2-T1	Time Testing - Notes Uploading to Firebase Cloud.	109
Table 6.2.2.2-T2	Time Testing - Retrieving Realtime Data.	111
Table 6.2.2.2-T3(1)	Unit Testing - Bone Interaction.	112
Table 6.2.2.2-T3(2)	Relationship between Swipe Direction and Bone Model Rotation Direction.	113
Table 6.2.2.2-T3(3)	Achievability Testing - Bone Rotation.	114
Table 6.2.2.2-T3(4)	Achievability Testing - Bone Cutting.	115
Table 6.2.2.2-T3(5)	Achievability Testing - Bone Scaling.	116

Table 6.2.2.3-T1	Unit Testing - Quiz.	116
Table 6.2.2.3-T2	Time Testing - Retrieving Score and Displaying Leaderboard.	119
Table 6.2.2.4-T1(1)	Unit Testing - Video Playing.	120
Table 6.2.2.4-T1(2)	Achievability Testing - Video Playing (Fullscreen & Minscreen).	121
Table 6.2.2.4-T1(3)	Achievability Testing - Video Playing (Start & Pause).	121
Table 6.2.2.4-T2	Unit Testing - General Information.	122
Table 6.2.2.6-T1	Unit Testing – Background Music.	125

LIST OF ABBREVIATIONS

<i>2D</i>	2-Dimensional
<i>3D</i>	3-Dimensional
<i>CT</i>	Computed Tomography
<i>CAD</i>	Computer-Aided Design
<i>AO/OTA</i>	Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association
<i>ORIF</i>	Open Reduction and Internal Fixation
<i>IM nail</i>	Intramedullary Nailing
<i>OS</i>	Operating System
<i>APK</i>	Android Package
<i>IDE</i>	Integrated Development Environment
<i>MesH</i>	Medical Subject Heading
<i>API</i>	Application Programming Interface

Chapter 1

Introduction

1.1 Background

The femur, also known as the thigh bone, is the strongest, longest, and heaviest bone in the human body. It plays an important role in supporting 30 times of human body weight and stabilizing the pace, as well as for humans to carry out several activities in daily life, such as walking, jumping, and running [1]. Even though the femur is so strong, it can be broken. For instance, [2] updated that people who are in a serious accident, such as a motorcycle crash that had resulted in high-impact injuries. Besides, long-distance runners may suffer a femoral shaft stress fracture because of bearing stress for a long time. Not only that, but older adults with osteopenia can also break their femur shaft, if they fall from a standing position. Osteopenia means the bone density and mass is lost but is not as severe as osteoporosis. Both osteopenia and osteoporosis have a lower level of bone density than normal. Bone mineral density (BMD) testing can be used to identify these diseases, where the T score for osteopenia is between -1 to -2.5, and for osteoporosis is -2.5 and lower. These diseases began without any symptoms and are difficult to be aware of. There are several factors that cause these diseases, such as aging, hormonal changes, smoking, excessive alcohol consumption, sedentary lifestyle, and genetics [21]. Women who are undergoing the menopausal transition period or postmenopausal women are also at a high risk to be diagnosed with osteopenia because the decrease in estrogen results in greater bone resorption than production [34]. Osteopenia and osteoporosis cannot be fully cured, but having a balanced diet and exercising regularly can control and slow down bone loss [21]. Figure 1.1 indicates the stages of osteoporosis.

Table 1.1-1: T score of osteopenia, osteoporosis and normal bone

	Normal	Osteopenia	Osteoporosis
T score (Bone density)	1 to -1	-1 to -2.5	-2.5 and lower

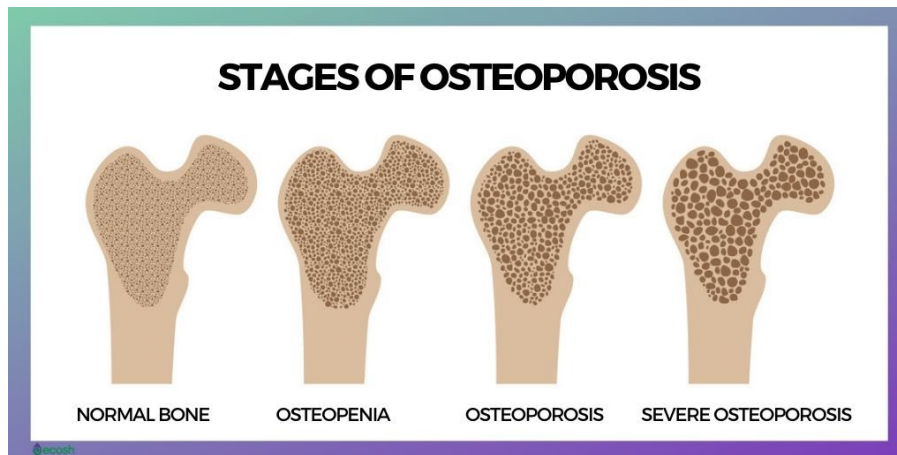


Figure 1.1-1: Stages of Osteoporosis

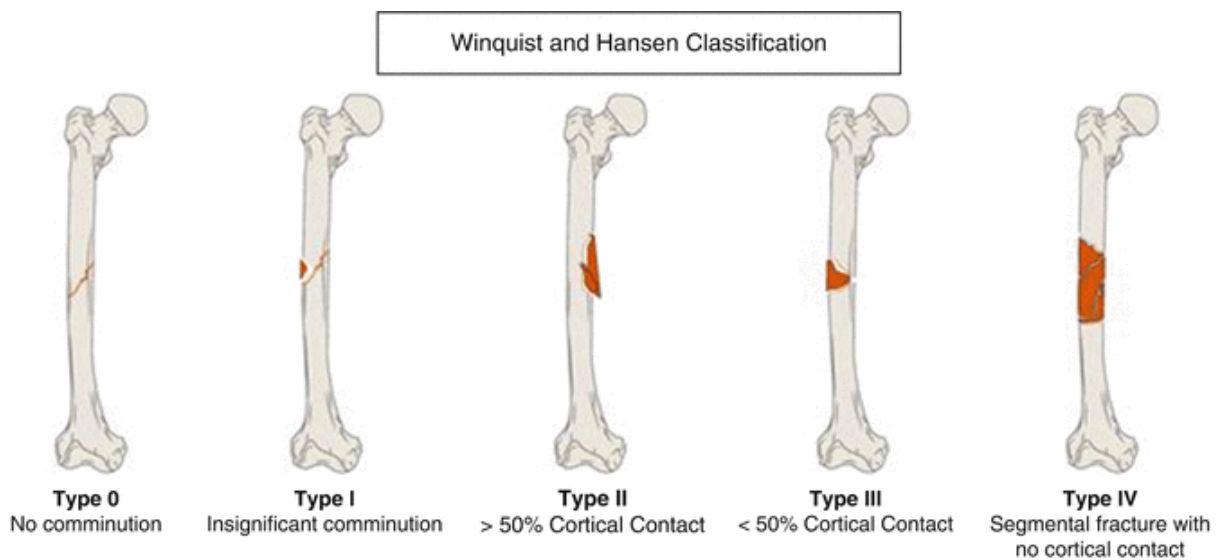


Figure 1.1-2 Classification of Femoral Shaft Fractures (Source: Torres, Lycans & Goel, 2017)

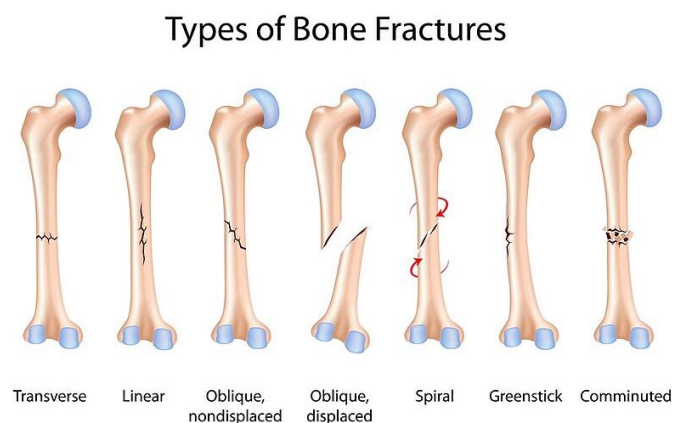
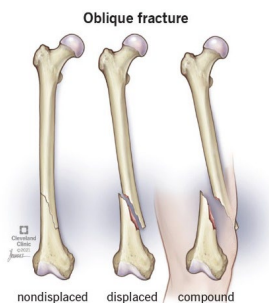


Figure 1.1-3 Types of Femoral Shaft Fractures (Source: MD, 2019)

As Figure 1.1-2 shows, the Winquist and Hansen classification that have been proposed in 1980 by Winquist divides femoral shaft fractures according to the degree of comminution, which is from the lightest, type 0 to the most serious, type IV. The purpose of the classification of femoral shaft fractures is to make management decisions for treatment, whether requires an intramedullary nail or open reduction [3]. A fracture without comminuted is known as type 0, a fracture with a small butterfly fragment that is less than a quarter of the bone's breadth is known as type I, and a fracture with a butterfly fragment that is half or less the width of the bone is known as type II, a fracture comminuted with a huge butterfly fragment that is more than half of the bone's breadth is known as type III, whereas, a fracture with significant comminuted of a whole bone section is known as type IV. Table 1.1-2 presented easy and understandable information along with the reference pictures.

Femoral shaft fractures can be further divided into different types, such as transverse, linear, oblique, spiral, greenstick, and comminuted as in Figure 1.1-3 shown [4]. According to Aaos.org, the most common types of femoral shaft fractures are transverse, oblique, spiral, comminuted, and open, where the open fracture represents the fragment of bone stuck out through the skin [5]. There are some descriptions and reference pictures of the types of fractures shown in Table 1.1-5. As a result of the high accuracy and reliability of AO/OTA Classification for long-bone fractures, it is most often used to classify the different types of fractures [35]. Different from Winquist and Hansen Classification, AO/OTA Classification classified femoral shaft fractures into 3 main types, which are simple (A), wedge (B), and complex (C) [22]. Since the femur is regarded as the third bone and the midshaft as the second segment, the AO/OTA classification delegates this fracture naming 32 [23].

Not only that, but the femoral shaft fractures can also be represented in different categories

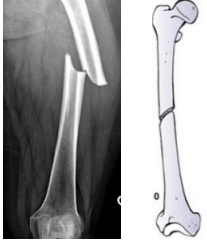
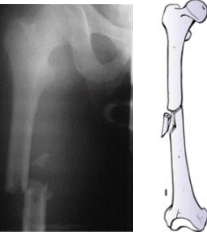
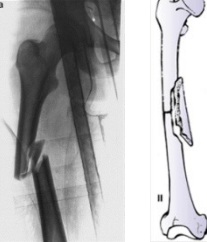


according to their seriousness and location, such as displaced, non-displaced, closed, and open as shown in Figure 1.1-4. For displaced fracture, the bone is snapped into 2 or more parts and moved out of alignment, while for non-displaced fracture, the bone is cracked without moving out of the alignment. For open fractures or compound fractures, the bone is broken through the skin, while for closed fractures or simple fractures, the bone

cracked without piercing the skin [33].

The Gustilo Anderson classification is another system for categorising the seriousness of open or compound fracture. It primarily classifies soft-tissue injuries from open fractures into 3 grades, namely Type I, Type II, and Type II, with Type III itself being further classified into 3 subgroups (Type IIIA, Type IIIB, Type IIIC) [58]. In Table 1.1-4, references images and damage levels for various open fracture grades according to Gustilo Anderson classification are presented.

Table 1.1-2: Winqvist & Hansen Classification

Winqvist and Hansen Classification [24]	
 <p>Figure 1.1-5: Type 0 of Winqvist & Hansen Classification</p>	<p>Type 0</p> <ul style="list-style-type: none"> No comminution
 <p>Figure 1.1-6: Type I of Winqvist & Hansen Classification</p>	<p>Type I</p> <ul style="list-style-type: none"> Small butterfly fragment < 25% of the bone's breath
 <p>Figure 1.1-7: Type II of Winqvist & Hansen Classification</p>	<p>Type II</p> <ul style="list-style-type: none"> Butterfly fragment < 50% of the bone's breath


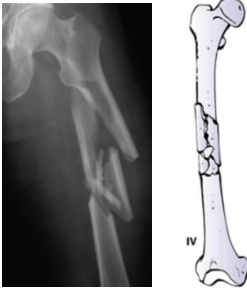
 <p>Figure 1.1-8: Type III of Winqvist & Hansen Classification</p>	<p>Type III</p> <ul style="list-style-type: none"> • Huge butterfly fragment > 50% of the bone's breadth
 <p>Figure 1.1-9: Type IV of Winqvist & Hansen Classification</p>	<p>Type IV</p> <ul style="list-style-type: none"> • Significant comminuted of a whole bone section

Table 1.1-3: AO/OTA Classification

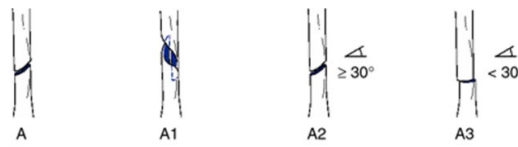
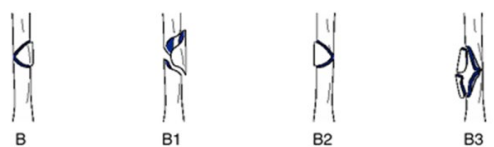
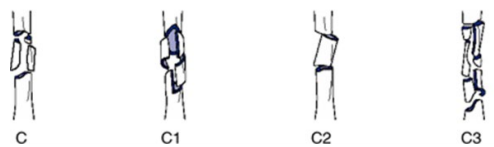
AO/OTA Classification [24]	
<p>Type 32A – Simple</p>  <p>Figure 1.1-10: AO/OTA Type 32A</p>	<p>A1 – Spiral A2 – Oblique, angle > 30 degrees A3 – Transverse, angle < 30 degrees Does not break the skin</p>
<p>Type 32B – Wedge</p>  <p>Figure 1.1-11: AO/OTA Type 32B</p>	<p>B1 – Spiral wedge B2 – Bending wedge B3 – Fragmented wedge</p>
<p>Type 32C – Complex</p>  <p>Figure 1.1-12: AO/OTA Type 32C</p>	<p>C1 – Spiral C2 – Segmental C3 – Irregular</p>

Table 1.1-4: Gustilo Anderson Classification






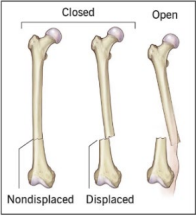









Gustilo Anderson Classification [58]	
<p>Type I</p>  <p><i>Figure 1.1-13: Type I of Gustilo Anderson Classification</i></p>	<ul style="list-style-type: none"> • Low energy • Wound size ≤ 1 cm • Minimal soft tissue damage • Minimal comminution of fracture
<p>Type II</p>  <p><i>Figure 1.1-14: Type II of Gustilo Anderson Classification</i></p>	<ul style="list-style-type: none"> • Moderate energy • Wound size between 1 – 10 cm • Moderate soft tissue damage • Moderate comminution of fracture
<p>Type III</p>  <p><i>Figure 1.1-15: Type IIIA of Gustilo Anderson Classification</i></p>  <p><i>Figure 1.1-16: Type IIIB of Gustilo Anderson Classification</i></p>  <p><i>Figure 1.1-17: Type IIIC of Gustilo Anderson Classification</i></p>	<ul style="list-style-type: none"> • High energy • Wound size > 10 cm • Extensive soft tissue damage • Severe comminution of fracture

Table 1.15: Most common types of femoral shaft fracture

Most Common Types of Femoral Shaft Fracture	
<p>Transverse fracture [26]</p>  <p>Figure 1.1-18: Transverse fracture(a)</p>  <p>Figure 1.1-19: Transverse fracture(b)</p>  <p>Figure 1.1-20: Transverse fracture(c)</p>	<ul style="list-style-type: none"> • The fracture line is perpendicular to the shaft of the femur. • Resulted when a strike delivers a significant amount of force that is perpendicular to the bone. • Fall under the category of complete fracture.
<p>Oblique fracture [28]</p>  <p>Figure 1.1-21: Displaced short oblique fracture</p>  <p>Figure 1.1-22: Long oblique fracture</p>	<ul style="list-style-type: none"> • The fracture line is broken through the bone at an angle with a curved or sloped pattern. • Resulted when force is applied to the bone at an angle other than a straight angle. • Can be sub-divided into short oblique and long oblique [25]. <ul style="list-style-type: none"> • Short oblique: fracture line lies between 30 degrees and 60 degrees from the bone's long axis • Long oblique: < 30 degrees in relation to the bone's long axis • Fall under the category of complete fracture.

 <p><i>Figure 1.1-23: Oblique fracture</i></p>	
<p>Spiral fracture [27]</p>  <p><i>Figure 1.1-24: Spiral fracture(a)</i></p>  <p><i>Figure 1.1-25: Spiral fracture(b)</i></p>	<ul style="list-style-type: none"> • The fracture line is wrapping around the bone and forms a corkscrew shape. • The bone breaks from the cortex to another side of the cortex, then to another side of the cortex, and finally back to the starting point of the cortex. • Resulted when a bone is subjected to an extremely strong twisting force. • Spiral fracture can be complete or partial.
<p>Comminuted fracture [29]</p>  <p><i>Figure 1.1-26: Comminuted fracture(a)</i></p>  <p><i>Figure 1.1-27: Comminuted fracture(b)</i></p>	<ul style="list-style-type: none"> • The bone is broken into several pieces. • Usually resulted from severe traumas, such as vehicle accidents and falls from great heights. • Fall under the category of complete fracture.

The types and classifications of fractures can be reviewed and revised by surgeons to apply the most suitable treatment for their patients. The treatments involve open reduction and closed reduction. For most serious and complicated cases, open reduction and internal fixation (ORIF) is applied, while a mild fracture or fracture on children is usually applied with closed reduction, Bachelor of Information Systems (Honours) Information Systems Engineering Faculty of Information and Communication Technology (Kampar Campus), UTAR

such as traction and casting. Internal fixation is always done with the technique of intramedullary nailing (IM nail), which is made up of the implantation of a metal rod, screw, or plate into the medullary cavity of the bone to provide resolute support for the broken bone. IM nail has also become the “gold standard” for treating femoral shaft fractures because it resulted in a short hospital stay, fast fracture union, and early functional use of the limb [36]. However, it is sometimes difficult for surgeons to apply the IM nail technique for some rare and complicated cases such as the bending shape of the femur and the diameter of the bone medullary cavity in patients may differ from the normal according to gender as well as changes in age, thus, this being the cases result in a mismatch of the equipment (metal rod) with the femur bone. It is for this reason that the maximum-minimum centre approach associated with some other techniques is utilised to calculate the thickness of the patient’s bone medullary cavity accurately, thereby applying the most appropriate size of metal rod for them [37].

Femoral shaft fracture is commonly used in several research for further studies. However, there is currently no complete and independent platform for people to learn and focus on the human femur and the types of femoral shaft fractures. Therefore, in this project, an educational portal with a 3D interactive atlas for the human femur along with the potential femoral shaft fractures is to be focused on this project. There are 3 different 3D atlas applications that have been reviewed in this research for gathering the idea of designing the platform of the educational portal for human femoral shaft fractures.

In this era of globalisation, digital technology has gradually covered the world, and education systems are no exception, especially in advanced countries. An educational portal has become significantly important since the internet is widely used by the world for learning purpose. Educational portal is a multi-function and informative platform designed for providing users the educational services [6]. It facilitates both the learners and educators because the learners can search for the information through the portal instead of attaching to the educators directly.

Because of the commonly used of human femur in multidisciplinary research for the purpose of experimental and computer simulation works, such as orthopaedic surgery, biomechanical engineering, biomedical engineering, rehabilitation, and medical implant technologies, the 3D model of human femur is constructed using a polygonal model which created from computed tomography (CT) data and exported to computer-aided design (CAD) for the creation of the bone surface [7]. This also means that 3D atlas is essential for learners to have a better

visualization on the anatomy of the human femur. Learners not only need to know the structures and functions for the anatomy part but also the spatial relationship to the surrounding structures. For example, the femur is divided into 3 parts, namely proximal (upper), shaft (middle), and distal (bottom), also, each part of them consists of different landmarks and surfaces. With the complication of the human femur, the 2-dimensional (2D) illustration may consist less efficient for learners to study and understand the entire femur structure, inversely, 3D atlas or models could improve learners' understanding as well as their imaging of the anatomy of the human femur. Besides, 2D illustration may need a lot of pages for showing the different capture of surfaces or angles of a particular anatomy in the textbook. Therefore, most of the time, the educators choose to teach with a plastic model in the laboratory for improving the understanding of learners. However, plastic models are occupying the spaces of the laboratory, and 3D atlas applications or platforms are then developed with the tablet and smartphone for learners to study anatomy more easily and interactively [8]. Besides, 3D atlas platforms also allow learners to study anatomy anywhere by using the tablet or smartphone.

1.2 Problem Statement and Motivation

The human femur bone is widely used for experimental and computer research; however, there is no independent learning platform for the human femur [7]. Besides, most of the 3D interactive anatomy platforms without including information on femoral shaft fractures. This may result in learners being unable to learn about the types and classifications of femoral shaft fractures through the platforms and having to search for another source to learn about it. Nowadays, everything goes online and is slowly replaced by technology. The 3D interactive anatomical atlas has also become indispensable for medical students or practitioners. However, the initial cost of a 3D platform or application can be expensive, and it may become a burden for learners [9]. This is because the use of real bone or organs for the creation of 3D models is costly [7]. Moreover, most medical students possess insufficient knowledge of anatomy since the time spent in the laboratory is less because they are only allowed to interact with the plastic model during class time. According to [10], there are more than half of the respondents from junior doctors say that there is insufficient integration of anatomy teaching in their clinical years. Due to this issue, most of the junior doctors possess lower confidence when they start to work, and this may lead to severe consequences and even the patient also distrusts them.

However, applications do not always provide accurate or trustworthy information compared to decades-old-anatomy textbooks [20].

Since the human femur is often employed in multidisciplinary research for different experiments, hence, a proper 3D model is needed to develop for reducing the cost of using the real bone. Besides, it is difficult to find real bone or plastic models with different types of femoral shaft fractures and there is currently no suitable platform for people to observe and understand them, hence, the need for a 3D learning platform for human femoral shaft fracture to be created is greater than ever. Furthermore, a 3D atlas platform is also essential for learners to understand and master the anatomical structure. This is because they need to provide accurate information and suitable treatments for the patients if their job is to be a medical worker. In addition, there is also research that found 3D tools are resulted in superior factual and spatial anatomy knowledge as compared to traditional approaches [11].

According to the fact found, the human femur is the strongest bone in the human body, and an adult male femur can withstand around 6,000 pounds of compressive force, which indicates that the femur is hardly to suffer a break [38]. Nevertheless, it can still be broken especially in a high-vehicle collision. In 2011, there is a study estimated that the rate of femoral shaft fracture for 100,000 people yearly was between 10 and 20 [39], while in 2015, there is research found femoral shaft fractures result from 1 to 2.9 million road traffic collisions yearly worldwide, and the mean of femoral shaft fracture incidence among the low and middle-income countries was between 15.7 and 45.5 out of 100,000 people yearly [40]. Besides, [39] also stated that there is an expected climb in the overall annual rate for femoral fractures, and the estimated number of femoral fracture incidences tends to be doubled by the year 2050. People should start to be alert on what type of fractures they may suffer, causes for the femoral fractures, treatments for femoral fractures, precautions for getting femoral fractures, as well as what they can do if they suffer a femoral fracture. This has also become one of the important reasons or motivations for dealing with this project.

1.3 Objectives

- To develop an informative educational mobile application for users to gain knowledge of the human femur in detail so that they can master the anatomy of the human femur easily.
 - Other than the name of structures, extra information such as potential femoral shaft fractures, different fracture classifications and medical treatments are also provided in this application.
- To develop a better learning experience for users to learn the anatomy of the human femur and its potential shaft fractures.
 - Develop in the form of Android mobile application so that enable users to learn anatomy anywhere and anytime with a mobile device.
 - Involve interactive 3D atlas for providing users a better sight of the anatomy of the human femur and its potential shaft fractures.
 - Develop the function of making their own notes, whereby making easier for them to revise on the part of the anatomy.
 - Quizzes are built into the application for users to test their current learning levels along with a leaderboard.
- To develop a completely free educational mobile application devoid of any advertisements so that lessen user strain from having to purchase pricey software or real bone which might be hard to come by.

1.4 Project Scope and Direction

The scope of this project is to develop an informative educational mobile application for human femoral shaft fractures which involves the 3D interactive model. The proposed educational mobile application is developed in the operating system of Android. There is a total of 6 types of bone fractures have been mentioned in the previous section; however, due to limited resources, only 4 of them will be presented in this application, which includes transverse

fracture, spiral fracture, comminuted fracture, and oblique fracture. All the types of fractures can be displaced or non-displaced according to the severity of injury.

This application mainly targets normal users without any medical background but who are interested in learning about human femoral shaft fractures, an example is science stream students from high school. Based on the Form 4 textbook, there is a chapter related to the skeletal systems, which is chapter 14 “Support and Movement in Humans and Animals” [59]. Even though they may not require learning deeply about the human femur, they can always refer to this application for additional information if they are interested. Besides, teachers can also use this application to impart extra knowledge to their students during classes. Perhaps this mobile application is able to increase the vividness and interest of the class.

Furthermore, this mobile application also supports offline access after downloading and installation. It will provide several functions that allow users to have a better sight for understanding the human femur as well as its potential shaft fractures with the treatments. The functions include allowing users to interact with the 3D bone model, such as rotating, scaling, cutting, and making their own notes. Additionally, there is a quiz section developed for the mobile application along with a leaderboard. The leaderboard feature is only available when users log in with an account. This mobile application is not compulsory for users to create and login with an account, but it is encouraged to do so for backing up their notes and quiz score for showing the leaderboard.

1.5 Contributions

Instead of using cadavers, a 3D interactive mobile application enables learners to view the structure of anatomy clearly in a comfortable environment. Besides, the price of a cadaver can be costly, and there is still an additional cost for maintaining the cadavers [12]. Furthermore, due to the short shelf lives of cadavers, the cadavers may start to decompose and become smelling within 1 or 2 days if without embalming chemicals [13]. Health issues are also mentioned as a drawback of using cadavers since embalming chemicals has been proved to have negative effects on human health [12]. Therefore, replacing the use of cadavers with 3D interactive atlas platforms can resolve the burden of cost as well as protect the learners and educators from harming their health. Also, it resolves the issues of plastic models that occupy

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the space of the laboratory. Other than that, it allows learners to continue studying anatomy at home, which also can resolve the issue in school or university that they are only permitted to use and observe the plastic model during class time. The use of 3D interactive atlas platforms has also addressed the problem of anatomy becoming more theoretical due to hard to get the real anatomy models. Furthermore, nowadays, there are several 3D anatomy learning platforms supporting for using offline after downloading it. This has also resolved the issue of network unstable and enabled users to learn anatomy anywhere. Apart from that, as time goes on, the information involved in 3D anatomy learning platforms becomes more trustworthy and high-quality, and hence, most learners can rely on the platforms to learn anatomy on a deeper level.

1.6 Report Organization

This report is arranged into 7 chapters, which are introduction, literature review, system methodology, system design, system implementation, system evaluation and discussion, as well as conclusion and recommendation accordingly. The content of the first chapter includes project background, problem statement and motivation, objectives, project scope and direction, and contributions. The second chapter includes review of technologies, and review of existing systems. The third chapter includes system methodology, system requirement, user requirement, and project timeline. The fourth chapter includes system design diagrams, such as flowchart, system architecture diagram, database architecture diagram, entity relationship diagram, use case diagram, and activity diagram. The fifth chapter includes software setup, project setting and configuration, system operation, and implementation issues and challenges. The sixth chapter includes overall system testing, such as testing methods, testing setup, result of testing, and objectives evaluation. The last chapter, the seventh chapter is all about the conclusion of the entire project and recommendation or future work.

Chapter 2

Literature Review

2.1 Review of the Technologies

2.1.1 Firmware/OS

There are 2 most popular and successful operating systems within the mobile field, which are Android and iOS. With the changing times along with the rise of high-advanced technology, the number of smartphone users worldwide has a rapid growth from 2 billion in the year of 2016 to 6.7 billion in the year of 2022 [41]. According to the most current statistic in September 2022, even though the usage percentage of Apple’s iOS is enlarging, Android currently still occupies most of the market share at around 72%, while iOS is only at around 28% [42]. However, the statistic of market share is not always a crucial consideration when creating an Android or iOS app. There is no clear winner when it comes to Android apps against iOS apps, the final decision of a company to produce an Android app, an iOS app, or even an app for both Android and iOS may also depend on the pros and cons of developing for each OS or resources they have available. The comparison between Android and iOS development is shown in the table below [43].

Table 2.1.1: Comparison between Android and iOS Development

	Android Development 	iOS Development 
Language used	<ul style="list-style-type: none">• Java• Kotlin• C/C++• C#• HTML, CSS, JavaScript• Python• Flutter, Dart• Corona	<ul style="list-style-type: none">• Swift• C#• Objective-C• Flutter, Dart• React Native• HTML5

Source system	Open, more features that are restricted in iOS can be developed in Android	Closed, more secure
Fragmentation	<ul style="list-style-type: none"> • With large number of different devices that can run with one responsive app • Devices may apply with the different version of OS 	<ul style="list-style-type: none"> • Most the devices use the same version of iOS (the OS is upgradable among all the devices)
Testing and debugging	Time consuming to test the app for all the version of OS for different devices	Less time to spend on testing the app developed, and easier for debugging
App publishing	Easier, only takes few hours to progress after uploading the Android Package (APK)	More difficult, as the app requires to first pass the high standard of testing
Cost	High, because there are more devices with different OS that need to be taken into consideration of	It can also involve a high cost at the beginning because the IDE of Xcode can only be used on Macs

2.1.2 Database



The database is a storage for storing different information on an application or website. Information types to be stored may include text, images, and documents. A database enables users to store their information persistently and to readily alter the data as they wish to. The database is divided into different categories, such as storing data locally (offline) or in a cloud (online). There are some considerations to choose suitable databases for storing data of an application or website, such as the structure of data, size of data, data model flexibility, database and platform support, scalability and speed, as well as data security [45].



Table 2.1.2-1: Comparison of Local Storage and Cloud Storage [53], [54]

	Local storage	Cloud storage
Characteristics	<ul style="list-style-type: none"> • Store data or information on-premise, such as in physical storage devices • Internet connection is not needed for accessing data in local storage 	<ul style="list-style-type: none"> • Data or information can be accessed over the internet connection
Data stored in	<ul style="list-style-type: none"> • Hard drive • Flash drive • Local file server • Network Attached Storage drive (NAS drive) 	<ul style="list-style-type: none"> • Online spaces with multiple servers
Pros	<ul style="list-style-type: none"> • Speedy as it need not internet connection • Security support as data can only be accessed by the devices' owner • Allow storing large amount of data with more capacity easily by using larger capacity of physical storage device 	<ul style="list-style-type: none"> • Cheaper for storing data as it is not needed for purchasing several external drives • More secure as the application of encryption algorithms that only those authorized personnel can access the data • Easier to access the data at anywhere as it is stored online • Support backing up data when the physical storage device is not accessible • Support file syncing when making every change

Cons	<ul style="list-style-type: none"> • Data can only be accessed through the physical storage devices • The cost for purchasing physical storage devices can be high • Unable to access the data stored in physical storage device anymore if it is damaged or being stole 	<ul style="list-style-type: none"> • The internet speed may affect the experience for accessing the data • The cloud server may be down sometime.
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Table 2.1.2-2: Description and Characteristics of Databases





Database	Description and Characteristics
Firebase [46], [52]  Firestore	<ul style="list-style-type: none"> • A backend as a service (BaaS)-based mobile and online app development platform sponsored by Google • A cloud-based NoSQL database • Possesses of authentication libraries that allow establishing of a functional authentication process with lesser time and fewer lines of code • Support real-time database • Support storing data and information on cloud • Support Google analytics • Great for real-time changes and data management
SQLite [47], [48]  SQLite	<ul style="list-style-type: none"> • Lightweight • A software library that provides Relational Database Management System (RDBMS) • Database files are stored on disk • Does not require a server for operation • With limited database size





<p>MySQL [49], [50]</p> 	<ul style="list-style-type: none"> • Type of RDBMS • Provides higher security as it possesses of a strong data security layer to keep critical information safe from intruders and passwords are encrypted • Compatible with many other operating systems, such as Windows, Linux, and UNIX • Does not require much RAM • Support integration of different programming language • Not particularly effective when dealing with large databases
<p>MongoDB [51], [52]</p> 	<ul style="list-style-type: none"> • Type of documented-oriented NoSQL database • Can be operated on-premises or in the cloud • Highly secure • Provides better performance in dealing with high volume data storage • Does not restricted by schema and is flexible to store any type of data • Support powerful search and indexing tools • Provides better performance as compared to traditional RDBMS • The feature of replication brings better stability and data availability • Memory usage may be inefficient when there are several data to be replicated • Great for quick data management

2.1.3 Programming Language

Since this project is planned to be developed as an Android mobile app, there will be some top languages for Android development to be reviewed. The languages include Java, Kotlin, C/C++, C#, Python, HTML, CSS, JavaScript, Dart, and Corona [44].

Table 2.1.3: Description and Characteristics of Programming Languages

Programming Language	Description and Characteristics
<p>Java</p> 	<ul style="list-style-type: none"> • Official language for Android app development before the Kotlin • Most supported language by Google • Consists of superb online community where developers can go for support easily if they encounter any issues • May be a complicated language for beginner to use
<p>Kotlin</p> 	<ul style="list-style-type: none"> • Replace Java to be the official language for Android app development since 2019 • Cross-platform programming language • Can interoperate with Java • Remove unnecessary features of Java <ul style="list-style-type: none"> • Null pointer exceptions • Semicolon ending in each of the line of code • Simpler than Java
<p>C/C++</p> 	<ul style="list-style-type: none"> • Android app development with Android Native Development (NDK) • Android app cannot be entirely developed in C++, but NDK can be used to implement portion of the app • More difficult to set up and much less flexible • May lead to more bugs
<p>C#</p> 	<ul style="list-style-type: none"> • Similar to Java • Consists of cleaner and simpler syntax than Java • Use .NET framework • With Xamarin that applied with C# and .NET framework, Android tools may be used to create native Android applications and share the code between different platforms

<p>Python</p> 	<ul style="list-style-type: none"> • Python is not natively supported by Android; however, a number of tools can be used to transform Python applications into Android Packages, for example, an open-source Python library namely “Kivy” is mainly used for developing mobile application.
<p>HTML, CSS, JavaScript</p> 	<ul style="list-style-type: none"> • Android apps can be developed using Adobe PhoneGap framework that is powered by Apache Cordova • Very little or no programming is needed, with the exception of JavaScript
<p>Dart</p> 	<ul style="list-style-type: none"> • Powered by Flutter framework • Designed by Google to be a client-optimized language for quick apps on any platform • Focuses on facilitating UI development for developers with tools like hot-reload, which allows them to see changes immediately as they are being made to the application
<p>Corona</p> 	<ul style="list-style-type: none"> • A software development kit can be used for developing Android apps using Lua • Corona Simulator: used to develop apps directly • Corona Native: used to integrate Lua code with Android Studio project to develop native feature-rich apps • Primarily used to create graphics apps and games • It has some limitations as compared to Java, but it is considerably simpler and has an easier learning curve

2.1.4 Summary of the Technology Review

In conclusion, this project is going to develop on the Android platform because the initial cost for developing an iOS application is high, which requires to use IDE of Xcode that only

available for Macs. Besides, there are some databases that have been reviewed, which include local and cloud storage. This project is only required to store some lightweight data, such as some texts for users to take some notes, and quiz score data. To prevent data loss and content unavailable when internet is not available, PlayerPrefs has been used to store the data locally, meanwhile, Firebase is applied for allowing users to retrieve their data while using another device with the same login account. PlayerPrefs acts as a scripting API in Unity that can be used in this project with ease for preserving permanent data in Unity, while Firebase is a cloud-based database that can store all the data in the cloud rather than on-premises. Since this project is planned to develop a mobile application that allows users to use it on multiple devices, the authentication libraries that are supported in Firebase have made it easy to identify users. With the backend services and SDKs, it allows saving users' information in the cloud and permitting them to retrieve the same data across different devices. Lastly, because the C# programming language is natively supported by Unity, it has been chosen for developing this project. Even though C# may not be as efficient as C++, it is easier than C++, and consists of maximum support, as there are a lot of resources available on the internet as compared to other programming languages.

2.2 Review of the Existing Systems/Applications

2.2.1 Anatomyka Skeleton (Source: Anatomyka, 2021)



Figure 2.2.1-1 Anatomyka Skeleton Home

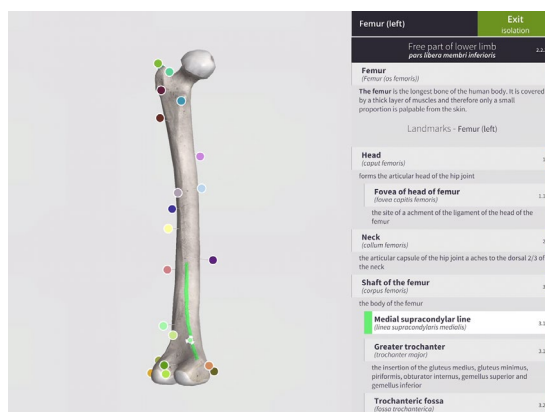


Figure 2.2.1-2 Anatomyka Skeleton Learning

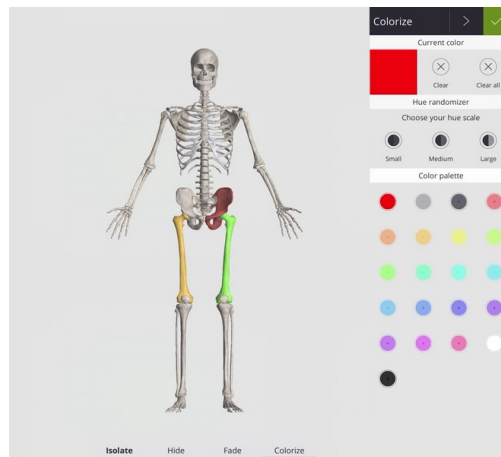


Figure 2.2.1-3 Anatomyka Skeleton Color

Anatomyka Skeleton is a 3D atlas interactive application accompanied with full human skeleton structures and information for users to view and learn. Anatomyka Skeleton is not considered a free platform since it consists of ads, and if users want to remove the ads, they need to pay for it. As the figures shown, the user interface of this platform is simple and clean. On the home page of Anatomyka Skeleton, users can click the top left button and turn into learning mode. After turning into the learning mode, users can isolate any part of the skeleton as shown in Figure 2.2.1-2. It is much easier for users to learn the landmarks of skeletal since there are pins in different colours. Besides, there is also a list of landmarks and descriptions that appear at the right-hand side of the learning page. Users can either click on the pin or the name of listed landmarks to learn the anatomy of the skeleton. There are also some clinical notes and interacting facts provided under the column of 'brief' after selecting one part of the skeleton. To view the structures clearly, users can zoom in the particular part of the skeleton. Moreover, the function for hiding, rotating, fading, scaling, and selecting are also allowed for users to manipulate the structures of the skeleton. Other than that, colours have been proven in a study that helps in learning and memorizing since they can increase human attention levels [15]. As Figure 2.2.1-3 shows, users can highlight the parts or structures of the skeleton with different colours which allows them to have a better learning experience. Furthermore, there is also a search function available in Anatomyka Skeleton for users to search a particular part or structure of the skeleton. However, there are no notes functions provided by Anatomyka Skeleton. Therefore, users are not able to re-label the skeleton or make some extra notes for the skeleton in the platform. This may cause inconvenience for users when they are learning without a pen and paper.

2.2.1.1 Strengths

Anatomyka Skeleton consists of several colours of pins for landmarking the skeletal. Besides, it allows users to highlight or colour the different parts of the anatomy. As stated before, colour is useful for learning. Besides, there is extra information provided which allows users to have a better understanding of the particular bone. The search function developed in Anatomyka Skeleton is also considered as a strength for users to search the part of bone if they are not sure where is the part located but only know the name.

2.2.1.2 Weaknesses

However, Anatomyka Skeleton does not develop a function for users to make their notes, which is troublesome for users to use the app at the same time while referring to their own notes on paper or notebook. Besides, it is annoying that users need to view an advertisement video after using the application for a few minutes.

2.2.2 Essential Skeleton 4 (Source: 3D4Medical, 2014)

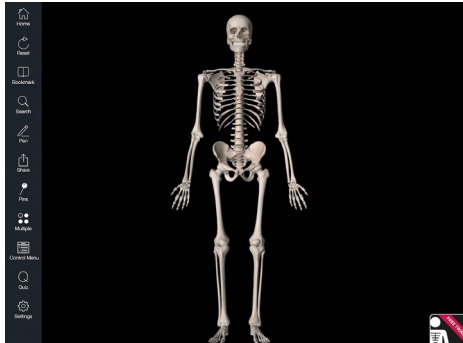


Figure 2.2.2-1 Essential Skeleton 4 Home

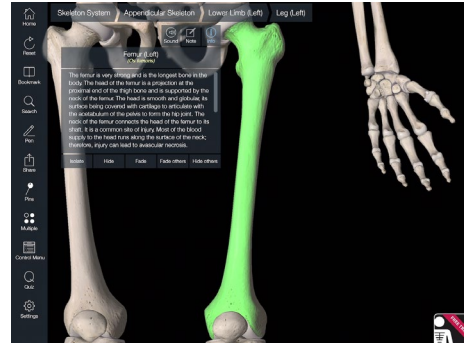


Figure 2.2.2-2 Essential Skeleton 4 Learning

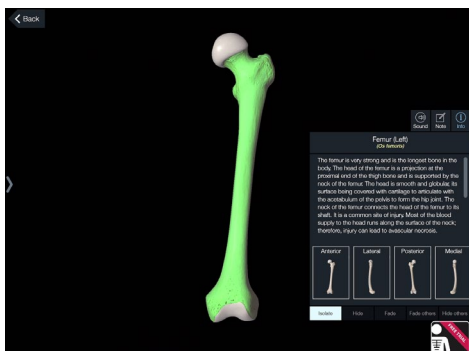


Figure 2.2.2-3 Essential Skeleton 4 Learning 2

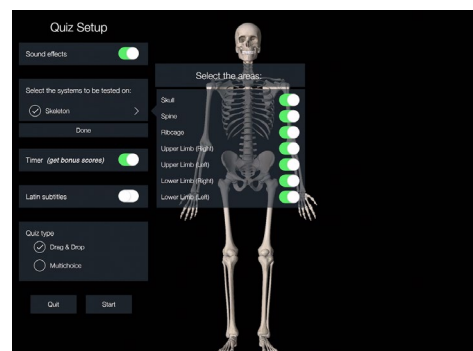


Figure 2.2.2-4 Essential Skeleton 4 Quiz

Essential Skeleton 4 is a completely free 3D atlas application for human skeleton developed by 3D4Medical for showing their new 3D technology and innovative design. Essential Skeleton 4 provides a common skeleton knowledge for users, which is only the name of skeletal structures and descriptions. There is no other information provided, such as clinical notes and potential injuries. As Figure 2.2.2-1 shows, Essential Skeleton 4 provides several functions for users to learn the human skeleton. Users can click on any part of the skeleton and start to learn for the skeleton as shown in Figure 2.2.2-2. After clicking the part or structure of the skeleton, users can choose to hide, fade, or isolate the skeleton. As in Figure 2.2.2-3, if users choose to isolate the part of the skeleton, there will be different surfaces to be shown to the users. Besides, users are also allowed to rotate the skeleton at different angles as they like. Similar to Anatomyka Skeleton, it allows user to zoom in the anatomy. Moreover, users can also type some notes for the part of the skeleton. However, there are no descriptions and labels of the landmarks provided for the particular part of the skeleton that may cause insufficient knowledge learned by the users. Even so, users can utilise the pin function to label the landmarks of the part of the skeleton, but the possibility for users to label the wrong name is high. Other than that, users can also test their learning level by doing a quick quiz after setting up the study area and type of quiz. There are 2 types of quizzes provided by Essential Skeleton 4, which include drag and drop as well as multichoice. Similar to Anatomyka Skeleton, there is also a search function involved in Essential Skeleton 4. Furthermore, can also bookmark the part of structures that they like, and this allows them to look back at the information easily.

2.2.2.1 Strengths

Essential Skeleton 4 is a fully free educational application and comes along with a strong notes function that allows users to add some extra text and pins rather than only read the information shown on the label. Besides, there are quizzes available for users to test their knowledge level.

2.2.2.2 Weaknesses

Even though there are strong features included in Essential Skeleton 4, there are also some weaknesses that it does not provide labelling for each part of the bone. This is not friendly for users who wish to learn and understand each part of the bone better. Essential Skeleton 4 was also developed without providing extra information on the bone for users to learn. Therefore, it is considered a not very informative educational application.

2.2.3 Complete Anatomy 2022 (Source: 3D4Medical, 2021)

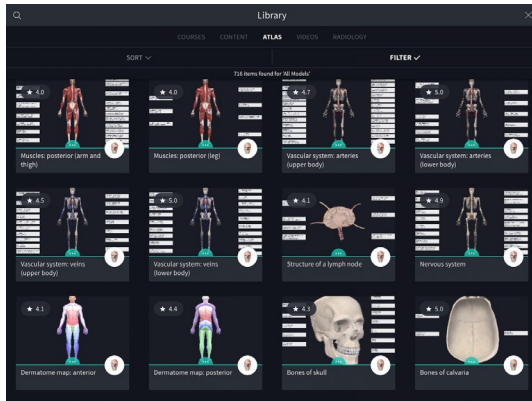


Figure 2.2.3-1 Complete Anatomy 3D Atlas

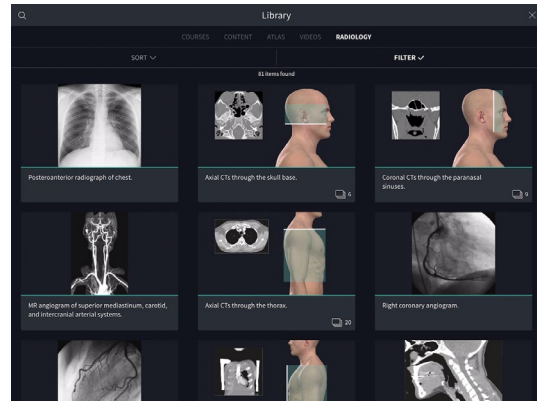


Figure 2.2.3-2 Complete Anatomy CT Scan

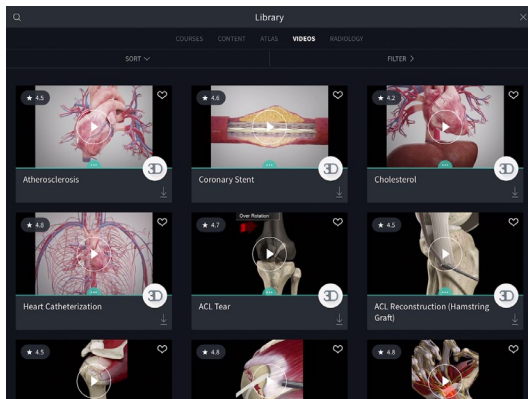


Figure 2.2.3-3 Complete Anatomy Videos

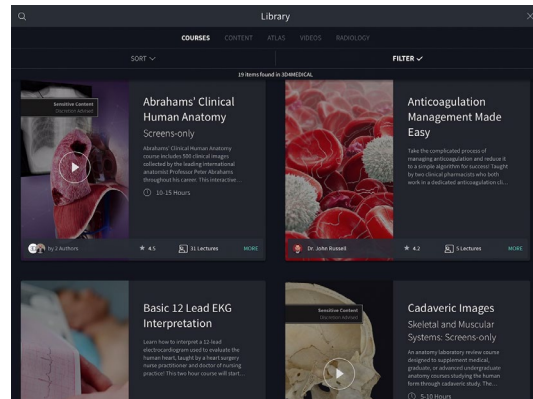


Figure 2.2.3-4 Complete Anatomy Lectures

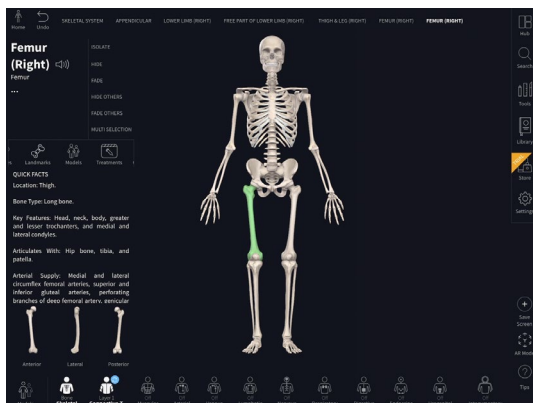


Figure 2.2.3-5 Complete Anatomy Skeleton

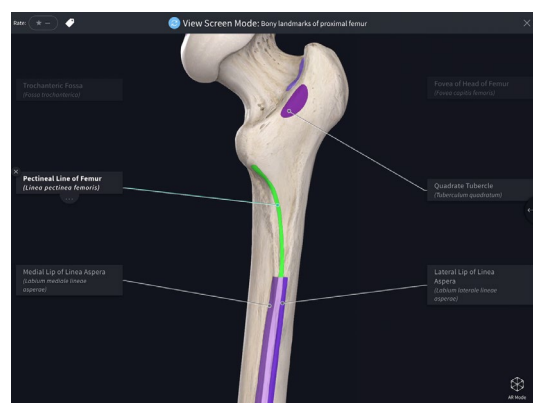


Figure 2.2.3-6 Complete Anatomy Learning

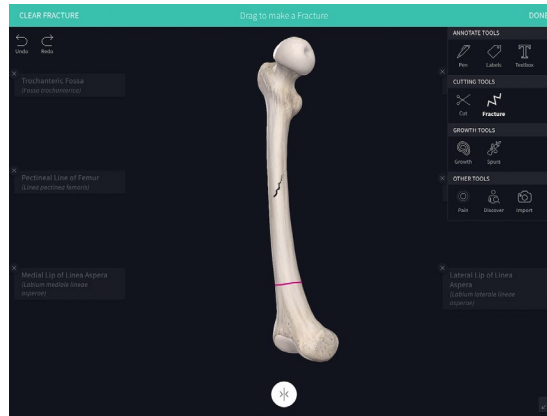


Figure 2.2.3-7 Complete Anatomy Modeling

Similar to Essential Skeleton 4, Complete Anatomy 2022 is the latest version of the 3D anatomy platform developed by 3D4Medical, but it is not free. It is widely recognized as the most functional 3D anatomy platform and is designed for remote learning and teaching purposes. Moreover, it consists of more than 17,000 structures of human anatomy and provides wonderful and complete features for users to study thoroughly on anatomy. There are also several functions and information included in this platform.

Other than interacting with anatomy, Complete Anatomy 2022 also provides several lectures and videos in the library. As Figure 2.2.3-1 shows, there are several human anatomy 3D atlas models provided. Users can search and choose which part of anatomy they want to learn, either the whole anatomy model or only part of it. After selecting a model, there will be several labels shown around the model, and users can click on the label or the surface of the model to view the description as shown in Figure 2.2.3-6. If users choose to learn the complete skeleton, there will be different information shown for users to read and learn, such as the basic description, features, and functions. It also contains the details for the parts, surfaces, and landmarks of the anatomy. Besides, there is also some videos included for treatments, conditions, exercises, and stretches for the chosen structure of the anatomy.

Furthermore, to disable the label around the model, users can inactivate the icon of labelling by clicking on it. Other than that, Complete Anatomy 2022 is so powerful that allowing users to make their own model by using the tools provided as shown in Figure 2.2.3-7. Not only for drawing and sketching, but it also provides tools for cutting the model of anatomy. After completing designing a new model, they can save the screen for further studying. Also, Complete Anatomy 2022 enables users to view and compare the CT scan and 3D model

parallelly on the same screen. Furthermore, AR mode and muscle motion are also supported in Complete Anatomy 2022.

2.2.3.1 Strengths

Complete Anatomy 2022 is a very powerful and comprehensive educational application for users to gain sufficient knowledge. It is powerful that advanced tools developed for allowing users to create their own models, add labels and add textbox as their notes. Besides, there is a lot of extra information and videos included in the application for users to study the bone. As for the current trend, it also supports AR. Not only that, but there are a lot of teaching resources, such as courses and radiology for users to gain a deep level of knowledge.

2.2.3.2 Weaknesses

However, Complete Anatomy 2022 is costly to use, and there is no function for users to test their knowledge level.

2.2.4 Summary of the Existing Systems and Proposed System

Table 2.2.4 Comparison between the reviewed systems and proposed system

Systems	Anatomyka Skeleton	Essential Skeleton 4	Complete Anatomy 2022	Proposed system
Interactive	✓	✓	✓	✓
Allow for making own notes	✗	<ul style="list-style-type: none"> - Can add some extra notes by typing in the label - Can add extra pins for doing own notes 	<ul style="list-style-type: none"> - Can make own model - Can add label and textbox 	✓

Description and labelling	✓	✓	✓	✓
Extra information provided	- Clinical notes - Facts	✗	- Clinical notes - Facts - Treatments videos - Condition videos - Exercise videos - Stretches videos	✓
Femoral shaft fractures information	✗	✗	✗	✓
AR support	✗	✗	✓	✗
Quiz provided	✗	✓	✗	✓
Allow highlighting the part of anatomy	✓	✗	✗	✓
Offline available	✓	✓	✓	✓
Cost	Free, but consists of a lot of advertisements	Free	Costly	Free

In a nutshell, the 3 reviewed systems consist of similar functions, and owning with different strengths and weaknesses. Based on the strengths and weaknesses of each of the reviewed

applications, providing sufficient information on the anatomy is essential for attracting more people to use the platform as it is worth the most in an education platform. Besides, making their own notes is also important for users to have a better understanding of the anatomy. Neilson also stated several tips for effective studying anatomy, and one of them is making clear notes [18]. Hence, adding more functions to the note page, such as adding text, adding pins, adding labels, drawing, and importing pictures are preferable for users to make their own notes. Other than making notes, the function of importing pictures allows users to import a 2D anatomy picture for comparing between 2D and 3D anatomy, thereby having a well understanding of the actual position of the part of the anatomy. Besides, since colours can catch the attention of the human brain, the highlighting function can also be integrated into the note page. This is because colours are important for stimulating users' memory, thereby allowing them to absorb the knowledge better. Moreover, the feature of quizzes or exercises also acting an important role for users to practice and test their current knowledge and provide chances to correct themselves if they are doing wrong. This is because people will usually learn more when they make mistakes.

2.2.5 Effects of using Mobile Application for Medical Education

Since the 1990s, mobile devices have been employed extensively in the digital age. At that time, there were 11 million users, and the number increased to an astonishing 2.5 billion in the year 2020 [55]. In the Covid-19 era, the development of mobile apps is also a growing trend in the education sector. Statista reports that the education sector is just behind the business and gaming categories in terms of popularity among mobile app categories worldwide [56]. Besides, medical education is also greatly aided by mobile applications, especially for healthcare professionals and students during their training and practice. Mobile application for medical education is deemed effective by [57] after gathering the most keywords from studies that have already been published and conducting medical subject heading (MeSH) phrase searches across 3 major databases, which are PubMed, Cochrane library, and Scopus by comparing with the traditional approach. The systematic review findings in [57] support that the use of mobile applications in medical education can improve the skill of students or learners regardless of the educational topics that are covered in different mobile applications. As proof,

52 studies were considered, out of which 29 evaluated changes in knowledge, 10 evaluated changes in skill level, and 13 evaluated changes in both knowledge level and skill level.

Mobile applications in medical education are currently employed by most researchers in the aspects of anatomy, surgery, respiratory conditions, dermatology, basic life support (BLS), pathology, dose calculation, as well as radiography. Since the mobile applications are designed for different topics, the built-in features will also differ accordingly, hence, the choice of users depends on their interests or professions. However, most of the mobile applications developed were web-based, and there is no offline support. Even while there is no discernible improvement in users' level of knowledge or skill enhancement using the application offline or online, the offline capability is crucial to increasing the users' acceptance and use of mobile applications, especially those from middle-income countries and rural areas [57].

By taking into account the low cost, increased versatility, reduced reliance on regional or site borders, online and offline capabilities, simulation capabilities, and ability to be used anywhere, mobile applications can be seen as an excellent supplementary tool in medical education [57].

Chapter 3

System Methodology/Approach OR System Model

3.1 System Methodology

A suitable system development methodology must be identified before starting to develop a system. Since this is a from zero design system, the requirements may not be clear enough, therefore, the methodology chosen for developing this project is the prototype model. The prototype model is a methodology that allows a prototype to be developed with minimal specifications where it then will be tested and modified according to the feedback from the user [19]. Besides, it can ensure the system requirements are met because the phases of design, prototyping, and evaluation phases are repeated unless the user is satisfied with the prototype designed.

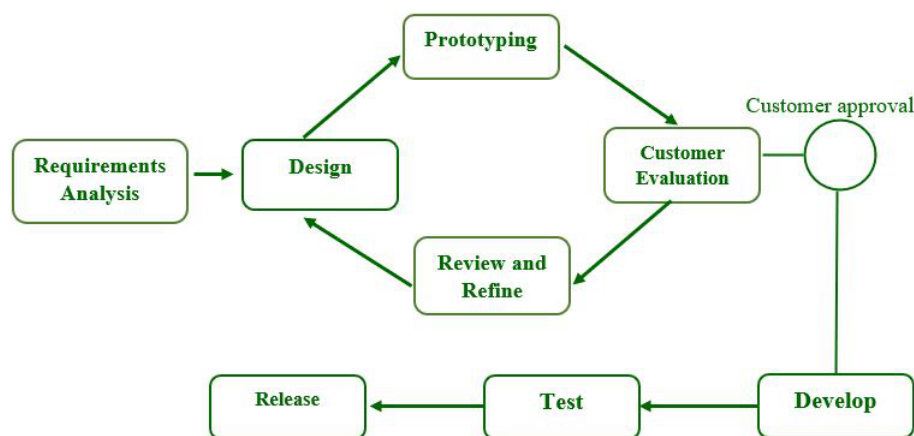


Figure 3.1: Methodology of Proposed System

Stage 1: Requirements Gathering and Analysis

First of all, the first task included in this project is identifying the user requirements, whereby the users or project owners are interviewed to understand what their expectation from the system is. By understanding the user requirements, the project scope can also be identified. Next, project feasibility is studied during this phase, which involves the technical, estimated cost, and profit of the project. If the project is fine for all, then it will come to the next stage.

Stage 2: Design, Prototyping and Evaluation (quick design)

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In stage 2, the design, prototyping, and testing phase are interleaved. An initial design of the system will be able to generate and come out with a prototype during the early stage 2. The prototype is for project owners to simulate with realistic software to ensure that the requirements are met and for evaluation. Usually, there will be additional requirements or requirement changes from the project owners. Then, another prototype will be developed for enhancement according to the feedback for project owners to simulate and gain again new feedback from them. These 3 phases are basically repeated until the project owners are satisfied with the system.

Stage 3: Implementation and Maintenance

The final system will be fully tested by both the developers and project owners. This is to ensure the system is performing well without any error as well as meets user requirements. Once passed through the testing phase, the system is ready to implement. After all is done, the maintenance phase may be carried out if there is any issue with the developed system.

3.2 System Requirement

3.2.1 Hardware

The hardware needed for completing this project involve a laptop and an android mobile device. A laptop is needed for develop a mobile application which support for the interactive 3D objects, while the android mobile device is needed for testing once the system is completed deployed. There are some specifications of laptop for developing the system:

Table 3.2.1 Specifications of Laptop

Description	Specifications
Model	Victus by HP Laptop 16-e0xxx
Processor	AMD Ryzen 5 5600H with Radeon Graphics @ 3.30 GHz
Operating System	Windows 11
Graphic	NVIDIA GeForce GTX 1650
Memory	16GB DDR4 RAM
Storage	512GB SATA SSD

3.2.2 Technologies Involved

Table 3.2.2 Tools and Software

Tools / Software	Description
Unity 	Unity is a cross-platform game engine that is currently commonly used in developing video games. It supports both the 2D and 3D environments for PC and mobile development. The native programming language used in Unity is C#. It will be used as the main development tool for developing the 3D educational mobile application for femoral shaft fractures.
Visual Studio 2022 	Visual Studio 2022 is an IDE mainly for the purpose of coding, and there are several languages supported in it, such as C#, C++, Python, Node.js, and others. It also can be used to develop mobile apps, websites, web apps, web services, and computer programs. It will be used for coding the scripts for making the mobile application function well.
Blender 	Blender is a free and open-source software for 3D environments, such as modelling, rigging, animation, rendering, compositing, motion tracking, as well as video editing. It will be utilised for modelling the types of fracture bones.
C# programming language 	C# is natively supported by Unity, and with Visual Studio 2022, some user-interaction features of the mobile application will be programmed in C#.
Firebase 	Firebase is a NoSQL cloud-hosted database that is used to store, sync, and query app data on a large scale. It will be used to sync data from PlayerPrefs and store it in the cloud to prevent data loss in the event that the application is removed or reinstalled.

3.3 User Requirements

3.3.1 Functional Requirement

➤ **3D Model interaction**

The educational application should allow users to interact with the 3D model, such as touching, rotating, and scaling.

➤ **Notes**

The educational application should allow users to add text for doing extra notes rather than view the information provided.

➤ **Quiz sections**

The educational application should allow users to take some quizzes or exercises for knowledge testing and consolidating their learning.

➤ **Video playing**

The educational application should allow users to play educational videos for gaining extra knowledge and enhance their understanding.

3.3.2 Non-Functional Requirement

➤ **Reliability**

The educational application should be reliable and provide high quality and accurate information. Besides, updating it if any information is being modified.

➤ **Usability**

The user interface of the educational application should be intuitive and easy to use, whereby the users will get how to use the application at a glance.

➤ **Performance**

The educational application should be quick responsive and allow offline usage.

3.4 Project Timeline

3.4.1 Project I Timeline

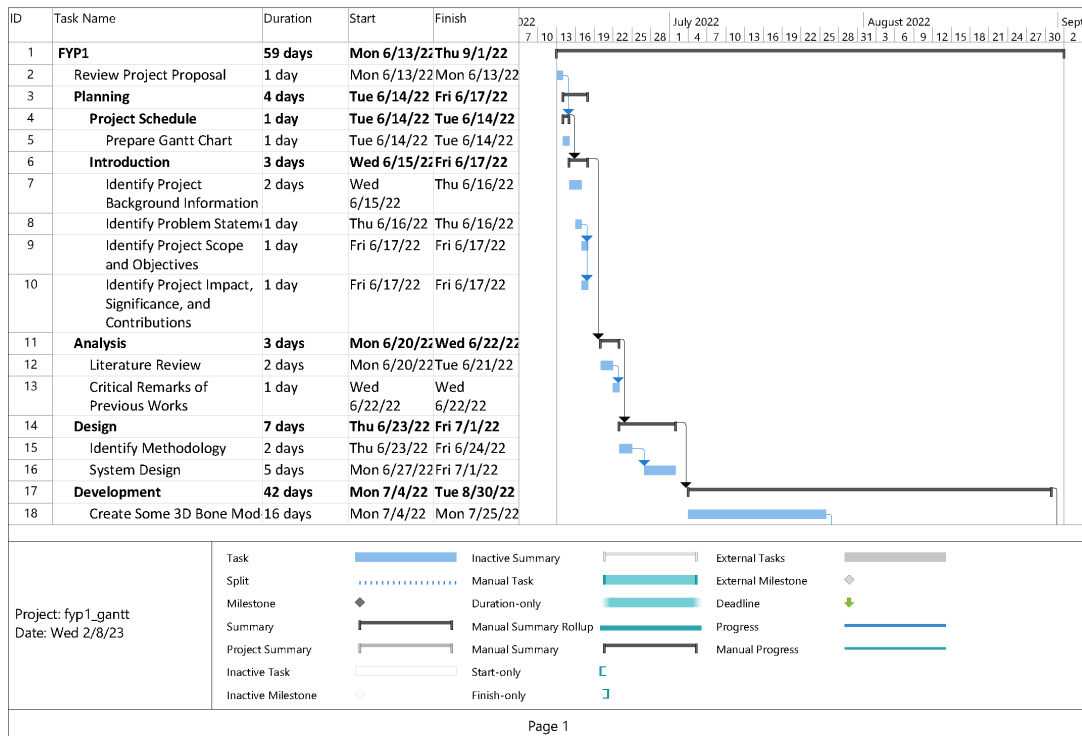


Figure 3.4.1-1: Timeline - Project I (Part 1)

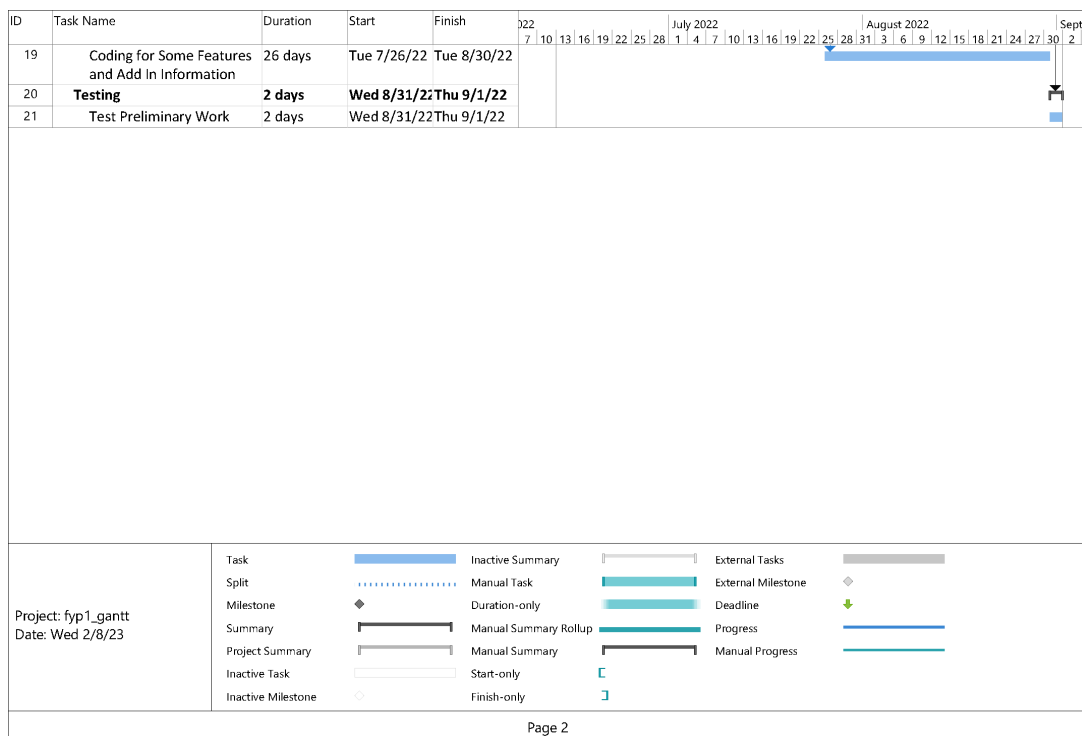


Figure 3.4.1-2: Timeline - Project I (Part 2)

3.4.2 Project II Timeline

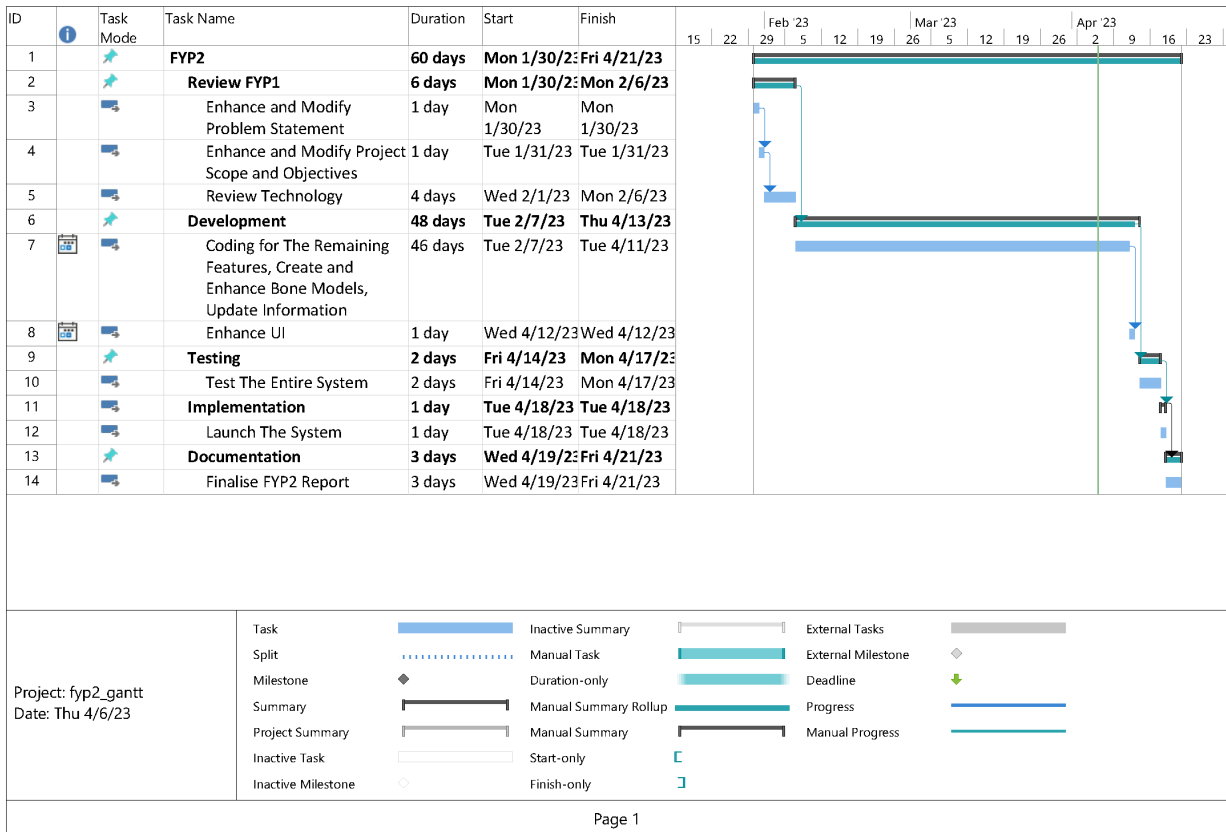


Figure 3.4.2: Timeline - Project II

Chapter 4

System Design

4.1 System Design Diagram

4.1.1 Flowchart

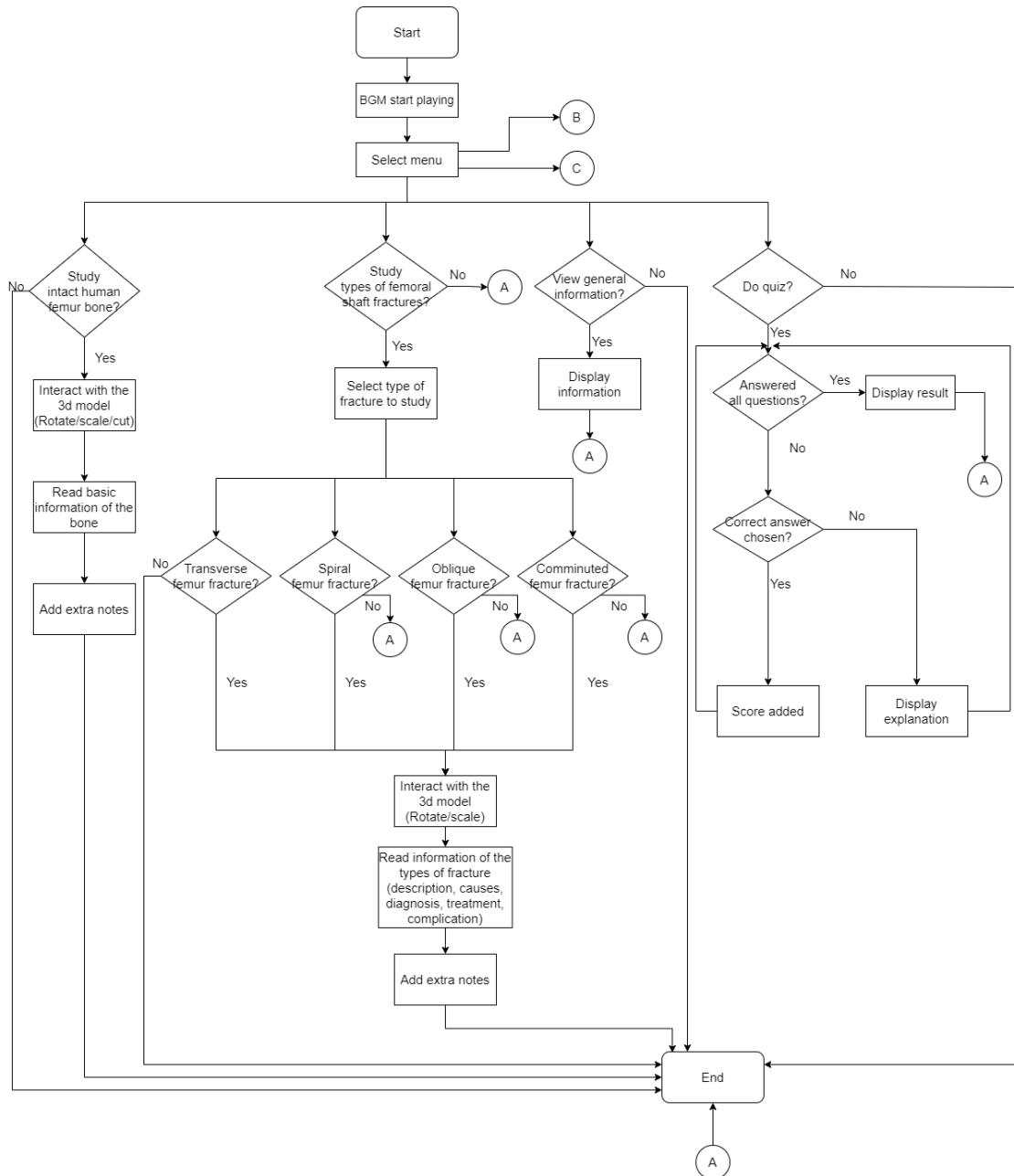


Figure 4.1.1-1: Flowchart - Part 1

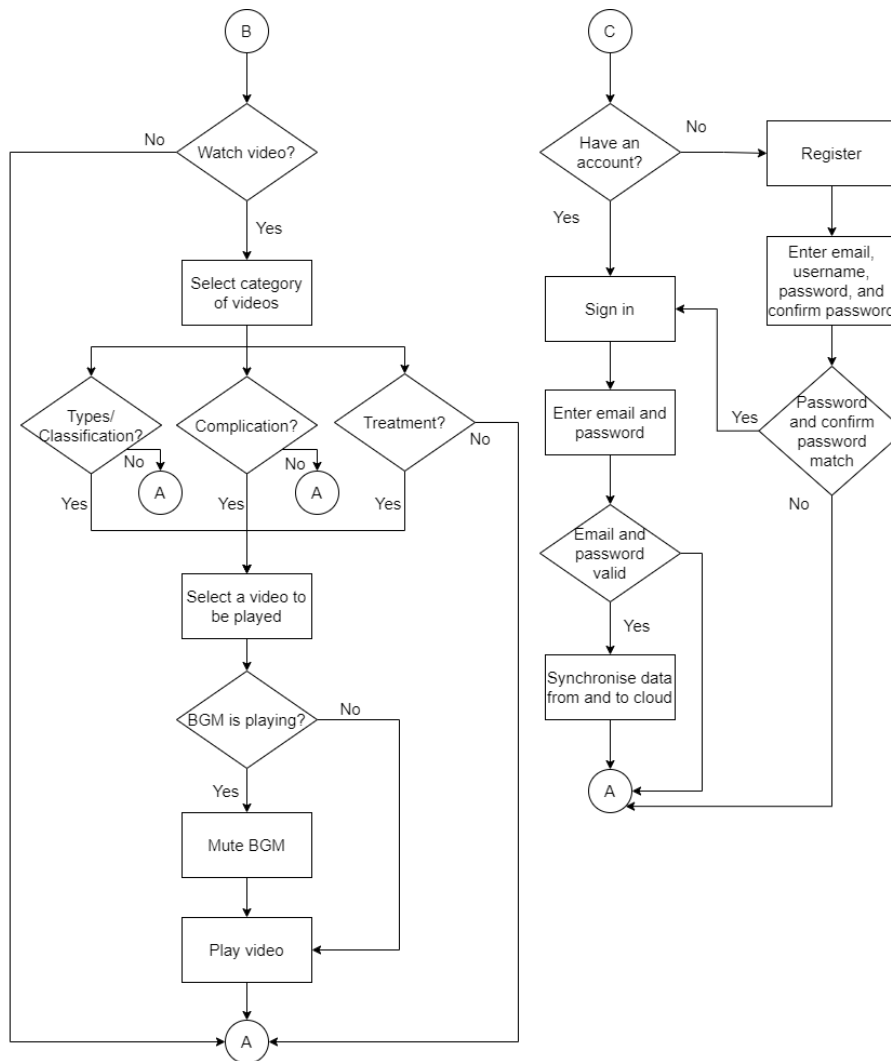


Figure 4.1.1-2: Flowchart - Part 2

Figure 4.1.1-1 and Figure 4.1.1-2 represent flowchart that shows how the app will function. The diagram clearly shows the flow of the application, which the users will allow to choose the menu and study the related information on human femur bone fracture. Users are allowed to interact with the bone, read information, and add extra notes accordingly. To gain more understanding, users can read general information and watch related videos by selecting the menu. Also, the quiz section will only end if users answer all the questions. All the data will then be synchronised from and to a cloud if users sign in with an account.

4.1.2 System Architecture Diagram

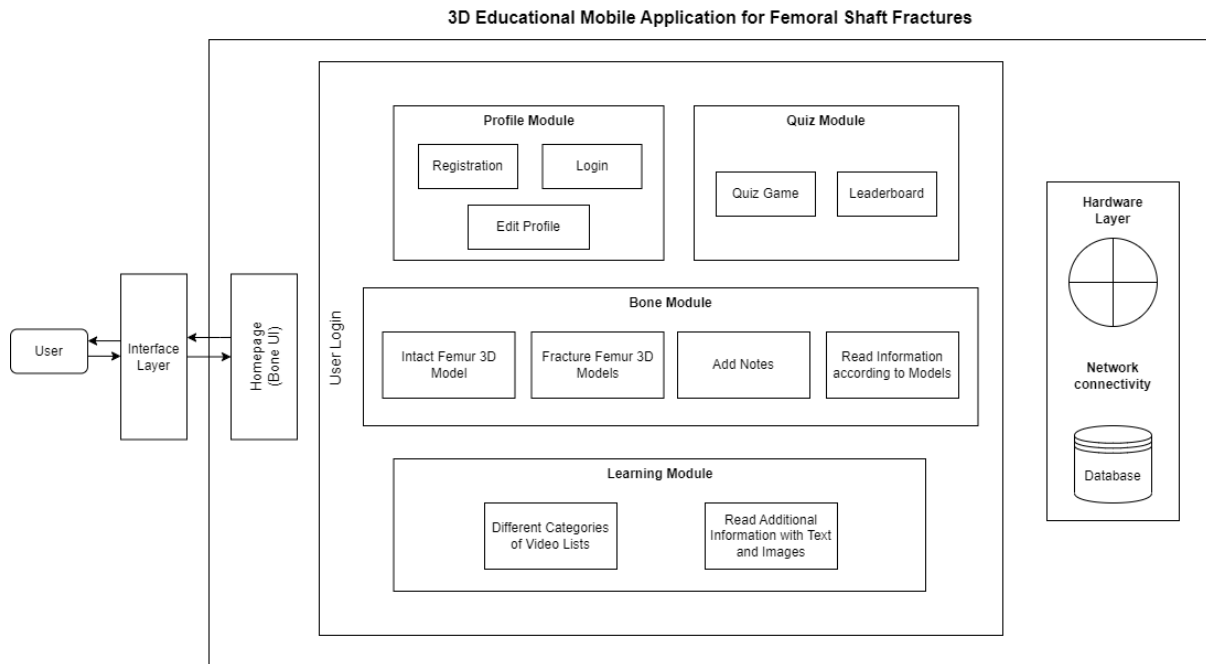


Figure 4.1.2: Architecture Diagram

Profile Module:

- Users can register a new account.
- Users can log in with their own account.
- Users can modify/delete their profile.

Quiz Module:

- Users can start the quiz game.
- Users can check their ranking through the leaderboard feature.

Bone Module:

- Users can interact with different bone models, such as rotating and scaling.
 - There is also a cutting feature for intact femur bone, which allows users to get some ideas about the inner part of bone.
- Users can interact with the intact femur bone and inner part of femur bone to get to know the name of each part of the bone structure.
- Users can read information regarding each of the types of bone.
- Users can add and save their notes as text for each of the types of bone.

- Users can resize and drag the pop-up windows of information and notes panel.

Learning Module:

- Users can play videos from different categories (types and classification, complication, treatment).
- Users can read additional information regarding the human femoral shaft fractures.
 - Information includes text and images.

The proposed system is to be developed as a 3D educational mobile application that includes 4 main modules, which are bone module, profile module, quiz module, and learning module, where the learning module is involving different categories of video lists and provide extra information with text and images for users to read. All the features will remain works even if users do not sign in with an account, except the leaderboard feature (under quiz module) and synchronise notes and quiz score into cloud. As mentioned previously, this application also supports offline usage, which means that users still can save their notes locally in their mobile device, same goes for the quiz score. The highest quiz score will be automatically saved locally in users' mobile device if they finish a quiz. Once they register and logged in with an account, all the local data will automatically upload to the cloud if the internet is available. The reason to develop this application with a cloud database is mainly to minimise the risk of data loss and make ease on data retrieving among different Android devices.

4.1.3 Database Architecture Diagram

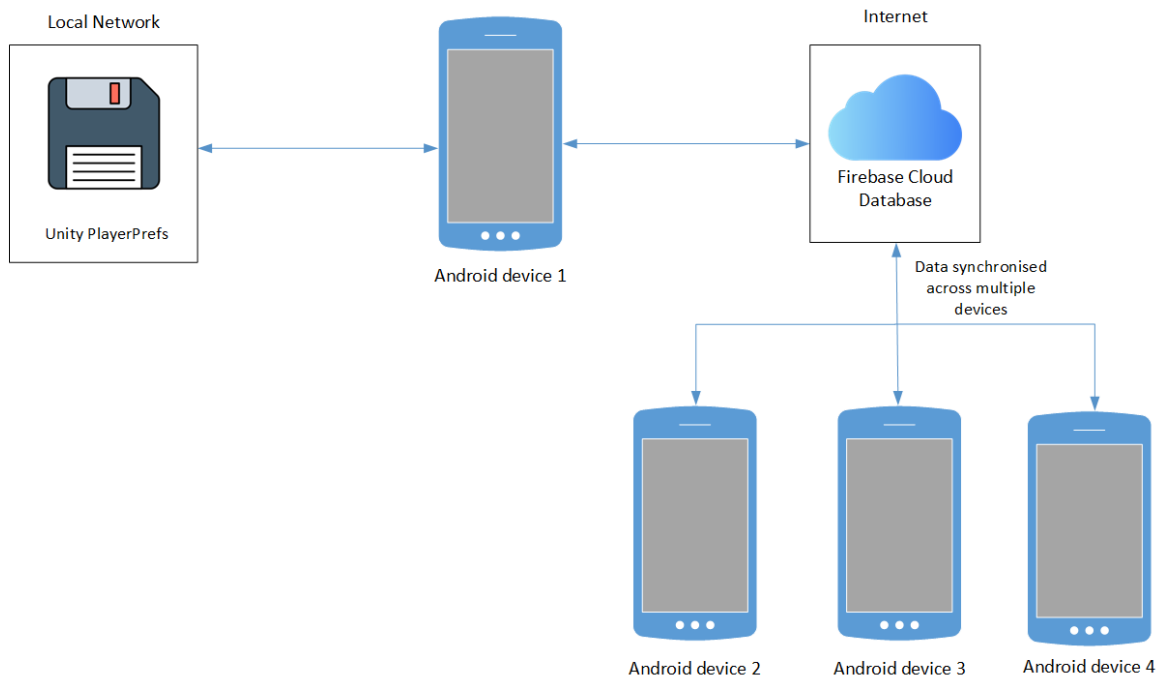


Figure 4.1.3: Database Architecture Diagram

Figure 4.1.3 shows the database architecture diagram. Users can retrieve data locally if the internet is unavailable. Users can still save their notes and quiz data locally by utilising the PlayerPrefs class provided by Unity. On the other hand, if the users are back online, the data can be synchronised manually and uploaded to the cloud database as a backup. If the data in the cloud is the newest version, the data will be retrieved from the cloud and replaced with the local instead of uploading the local data to the cloud. Besides, users can also get realtime data or live data if there is another device that is connecting to the same account and is currently editing the data. As a result, the risk of data loss can be minimised and it allows users to use other Android devices for continuing their learning state.

4.1.4 Entity Relationship Diagram

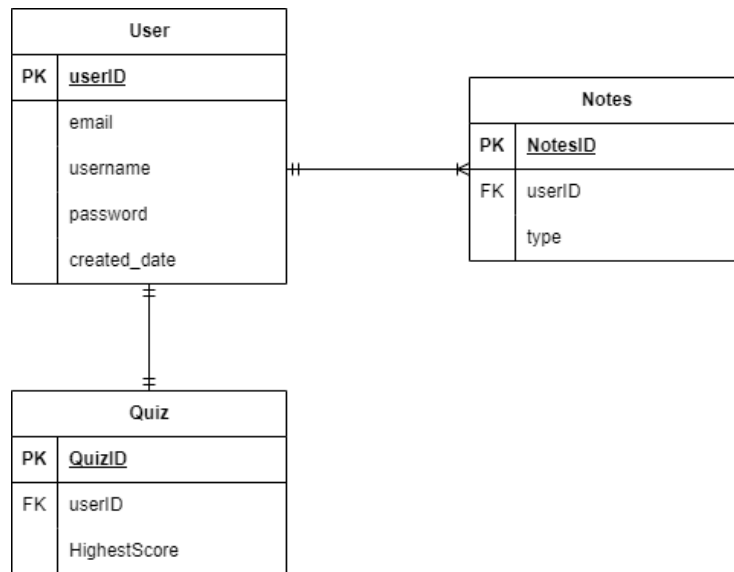


Figure 4.1.4: Entity Relationship Diagram

There is only a simple database involved in this proposed system. The main entities are user, notes, and quiz. A user can add text as notes for different types of bone fractures, an intact femur bone, as well as inner part of human femur bone. Besides, a user has the highest quiz score as 0 by default after registration until they start a quiz and get a higher score.

4.1.5 Use Case Diagram and Description

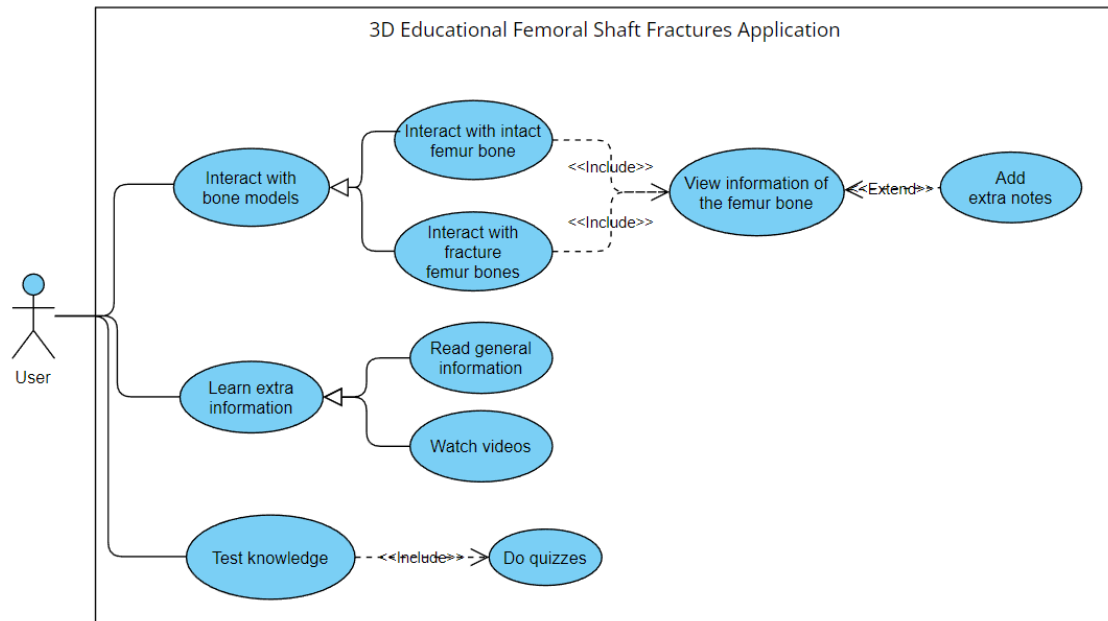


Figure 4.1.5 Use Case Diagram

Figure 4.1.5 shows how the users can interact with the application, whereby the users can interact with the bone models for having a better view of the bone structure. While studying, they can also read the information of each of the bone models and add extra notes. Besides, users can learn extra information by reading the general information and watching videos. Additionally, they can test their knowledge by attempting the quiz section.

4.1.6 Activity Diagram

4.1.6.1 Intact Femur Bone Activity Diagram

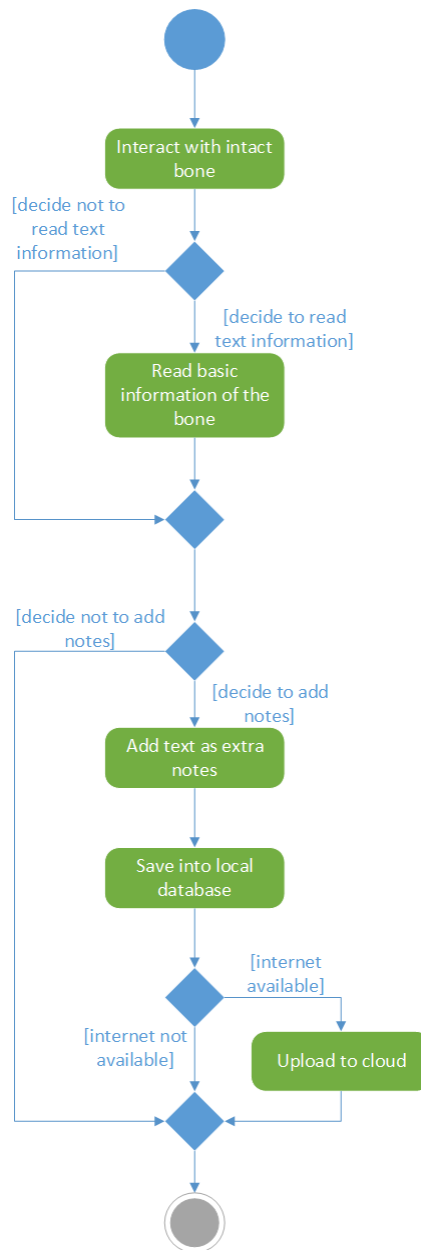


Figure 4.1.6.1: Activity Diagram - Intact Femur Bone

Figure 4.1.6.1 shows the activity flow of the intact femur bone module. The users can interact directly with the bone, such as scaling, rotating, and cutting. While users interact with the 3D object of the femur bone, there are labels for different parts or structures of the bone. Then, text information is available for users to decide whether to read through. The users can also decide to add extra notes if they wish to. After adding text as extra notes, the notes then can be stored

inside the local database. If users are logged in with an account and is connected to the internet, the notes will automatically be saved and upload to the cloud.

4.1.6.2 Fracture Femur Bone Activity Diagram

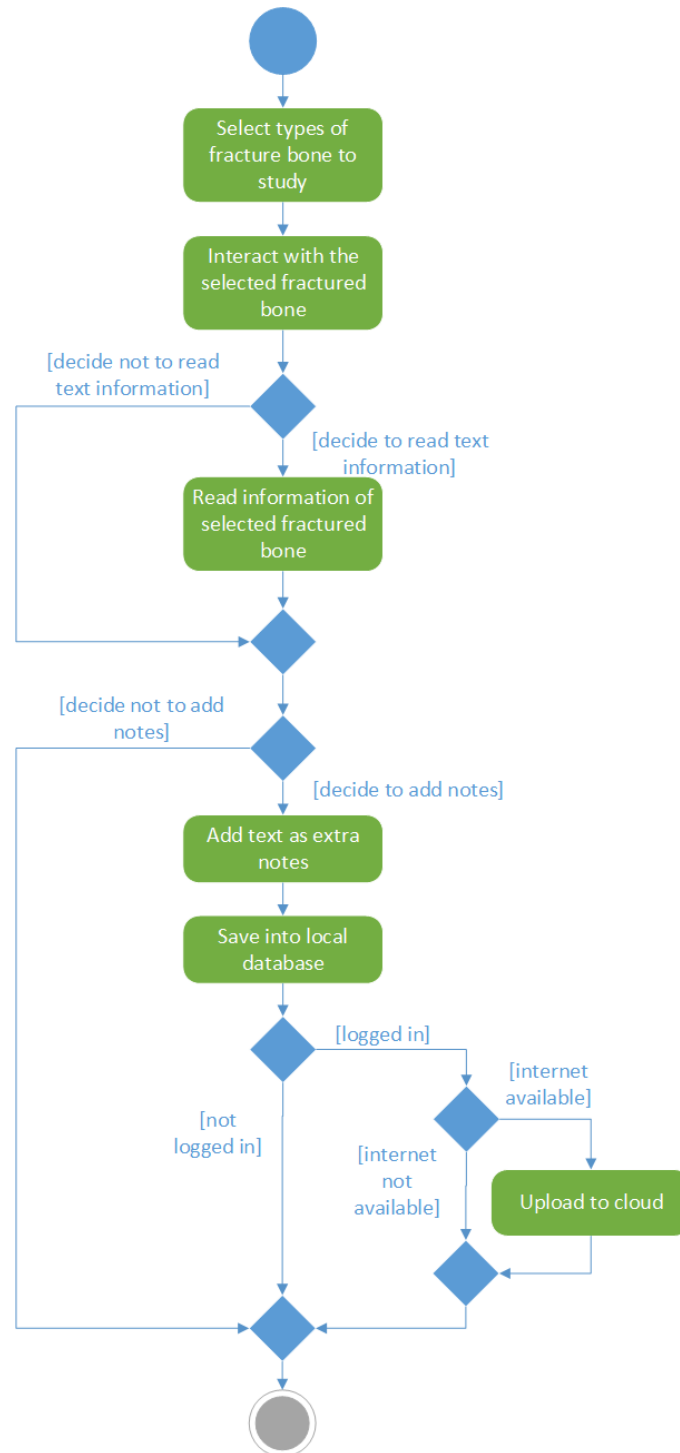


Figure 4.1.6.2: Activity Diagram - Fracture Femur Bone

Figure 4.1.6.2 shows the activity flow of the fracture femur bone module. The users can select any type of fractured bone that they wish to learn about, then interact with the bone. After that, same as in the previous module, users can decide if to read the text information or not. Then, decide to add text as extra notes. If users are logged in with an account and is connected to the internet, the notes will automatically save and upload to the cloud.

4.1.6.3 Quiz Activity Diagram

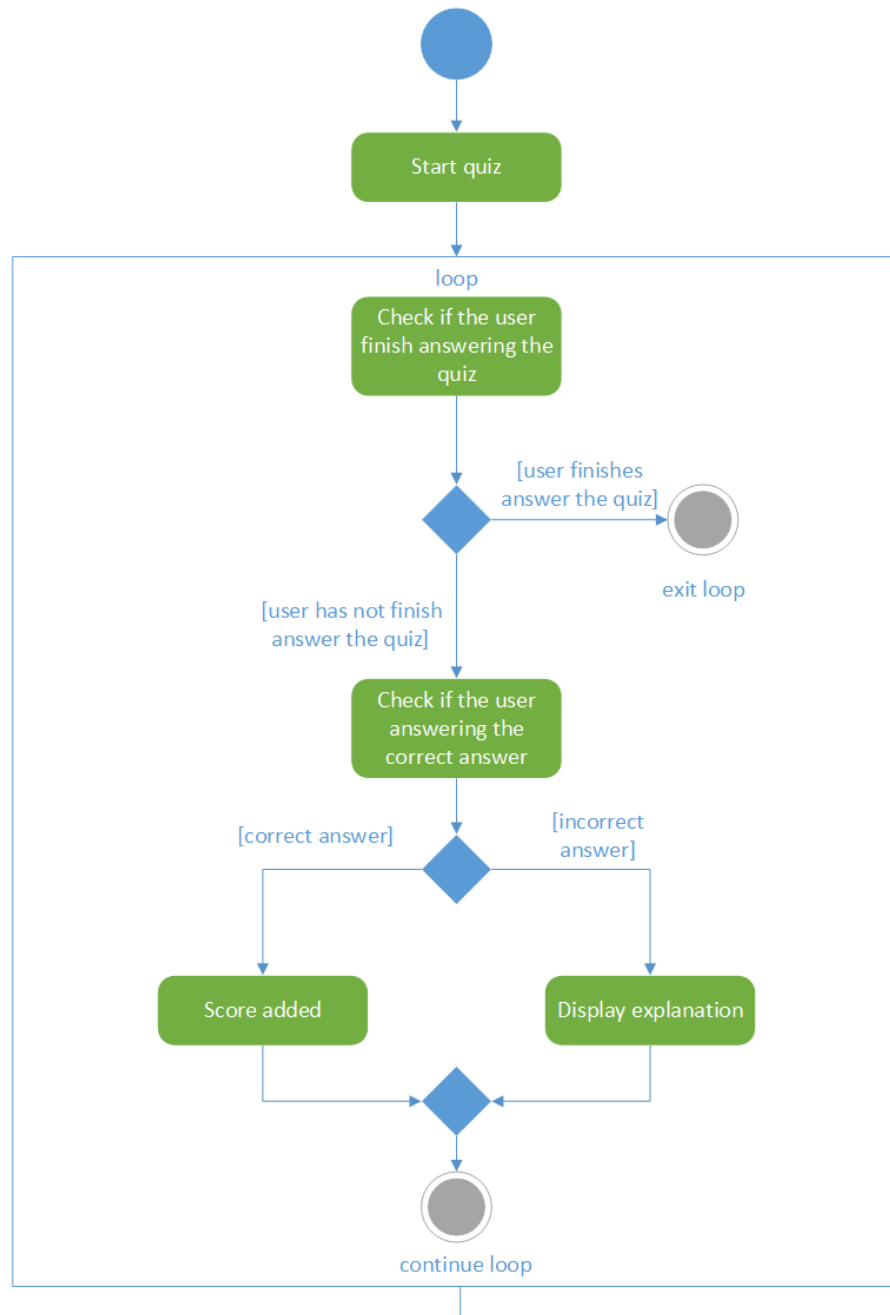


Figure 4.1.6.3-1: Activity Diagram - Quiz (Part 1)

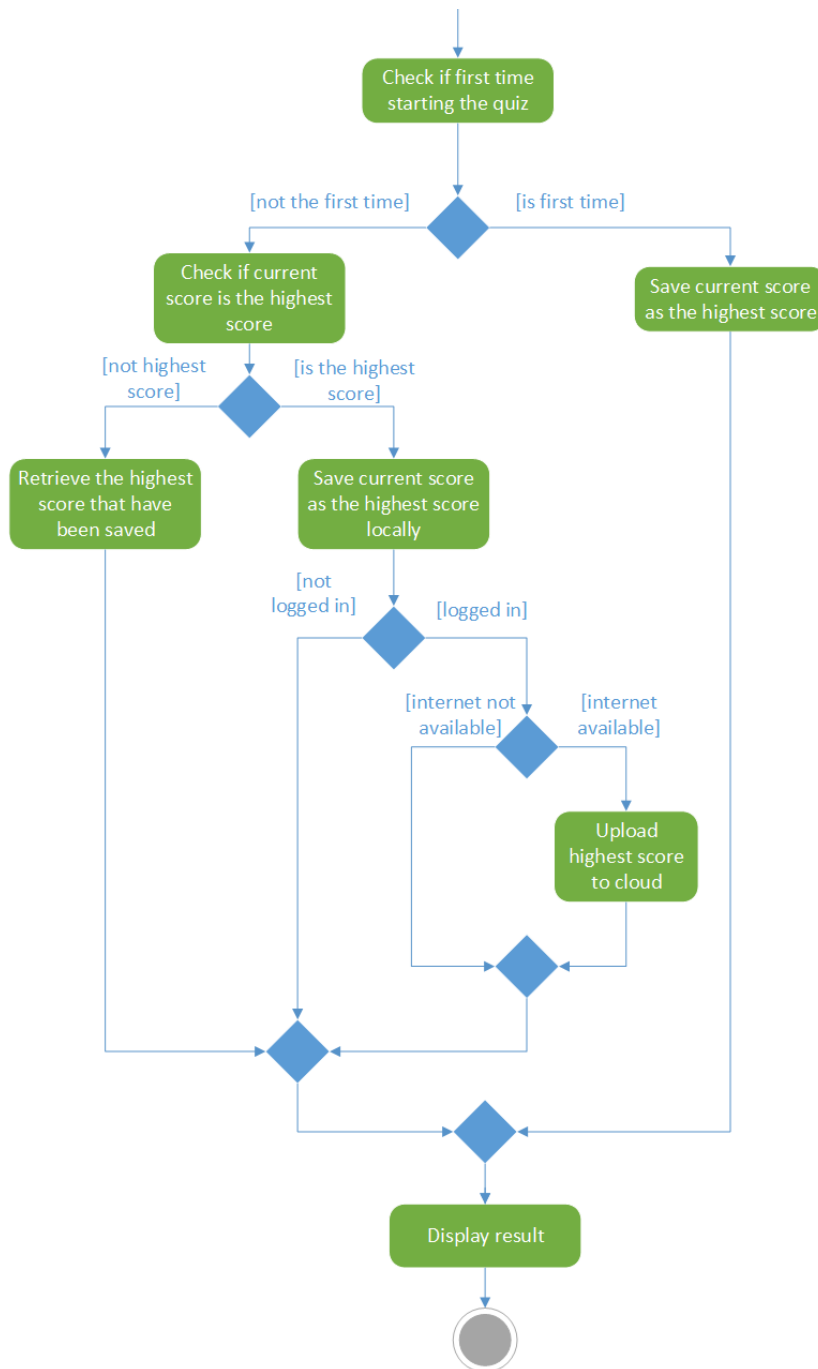


Figure 4.1.6.3-2: Activity Diagram - Quiz (Part 2)

Figure 4.1.6.3-1 and Figure 4.1.6.3-2 show the flow of the quiz module. Firstly, the system will check if the users have answered all the questions, if they are not, the system will continuously check whether the users had answered the correct answer. If yes, scores will be added, else there will be an explanation shown to users. Once the users have done all the questions, the system will then check whether it is the first time the users started the quiz. Before displaying

the result to users, it will check if the user has logged in and the internet is available. If the internet is available, it will then upload the highest score to the cloud.

4.1.6.4 Account Registration Activity Diagram

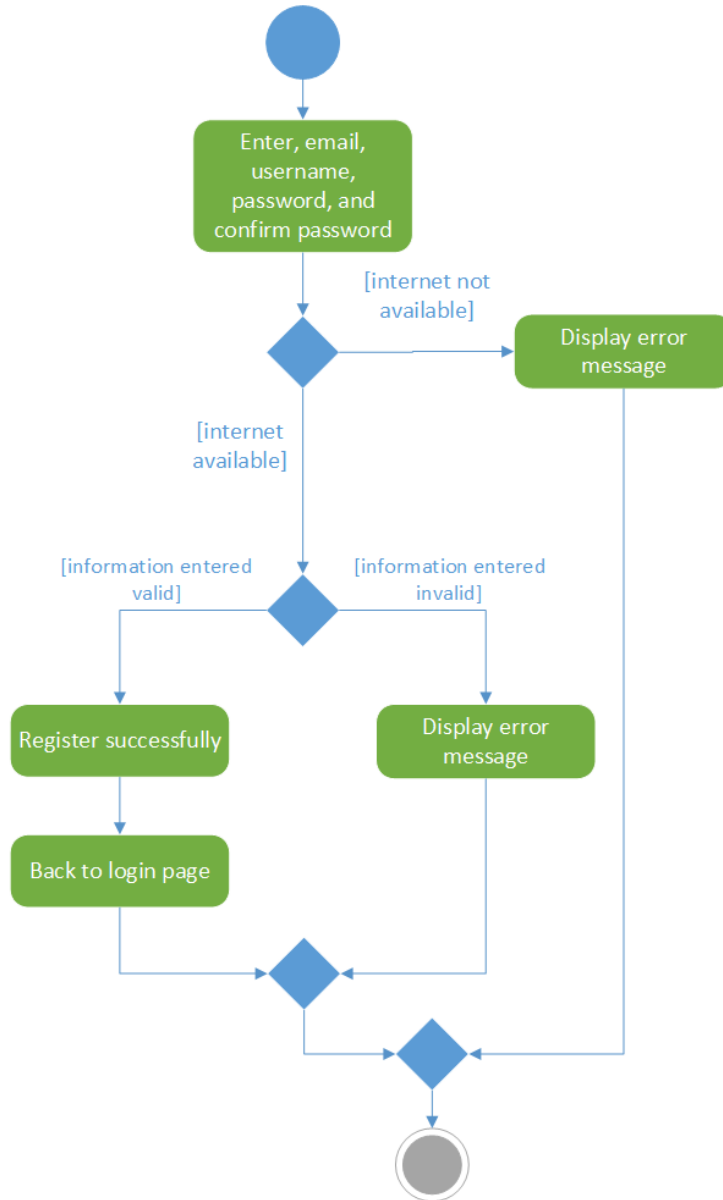


Figure 4.1.6.4: Activity Diagram - Account Registration

Figure 4.1.6.4 shows the flow of account registration. Users can register an account with their email, username, and password. To ensure the password entered by the users is correct, there is another field that requires the users to re-enter their password for confirmation. If the email entered is valid, and both the password and confirm password match, the account will be

registered successfully and turned back to the login page automatically. On the other hand, if any of the information entered is invalid, an error message will display.

4.1.6.5 Login Activity Diagram

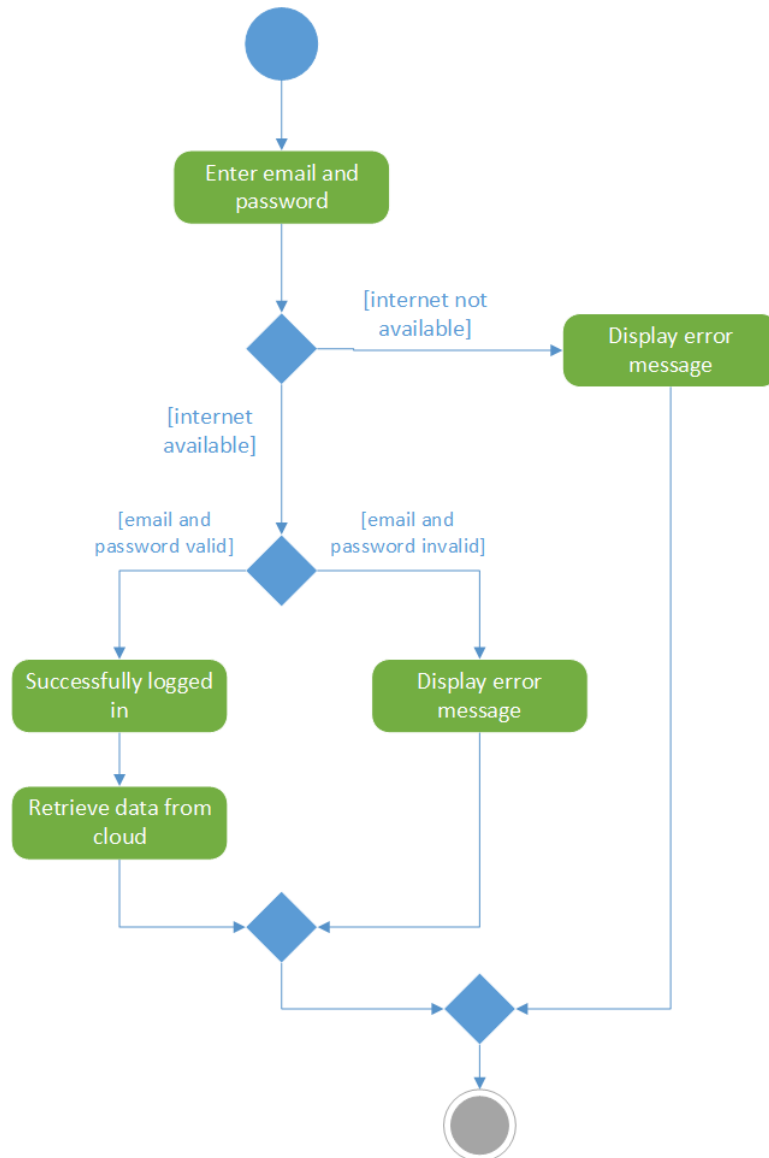


Figure 4.1.6.5: Activity Diagram - Login

Figure 4.1.6.5 shows the login flow. Users require to enter their email and password that have been registered previously. If the email and password are valid, the users will be able to login to the system successfully, or else, the error message will be displayed.

4.1.6.6 Forgot Password Activity Diagram

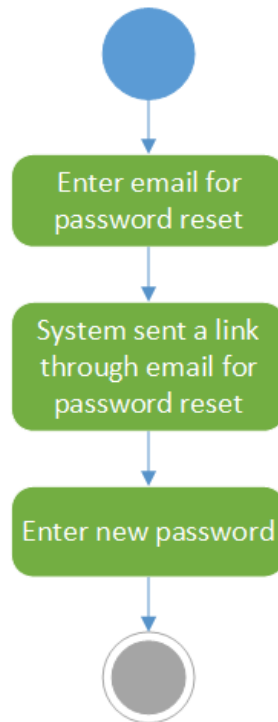


Figure 4.1.6.6: Activity Diagram - Forgot Password

Figure 4.1.6.6 shows the flow of forgotten passwords when logging in to the system. If the users had forgotten their password, they can easily reset their password by entering their registered email. Then, the system will send a link to the users' email, and they can reset their password by clicking on the link.

4.1.6.7 Profile Modification Activity Diagram

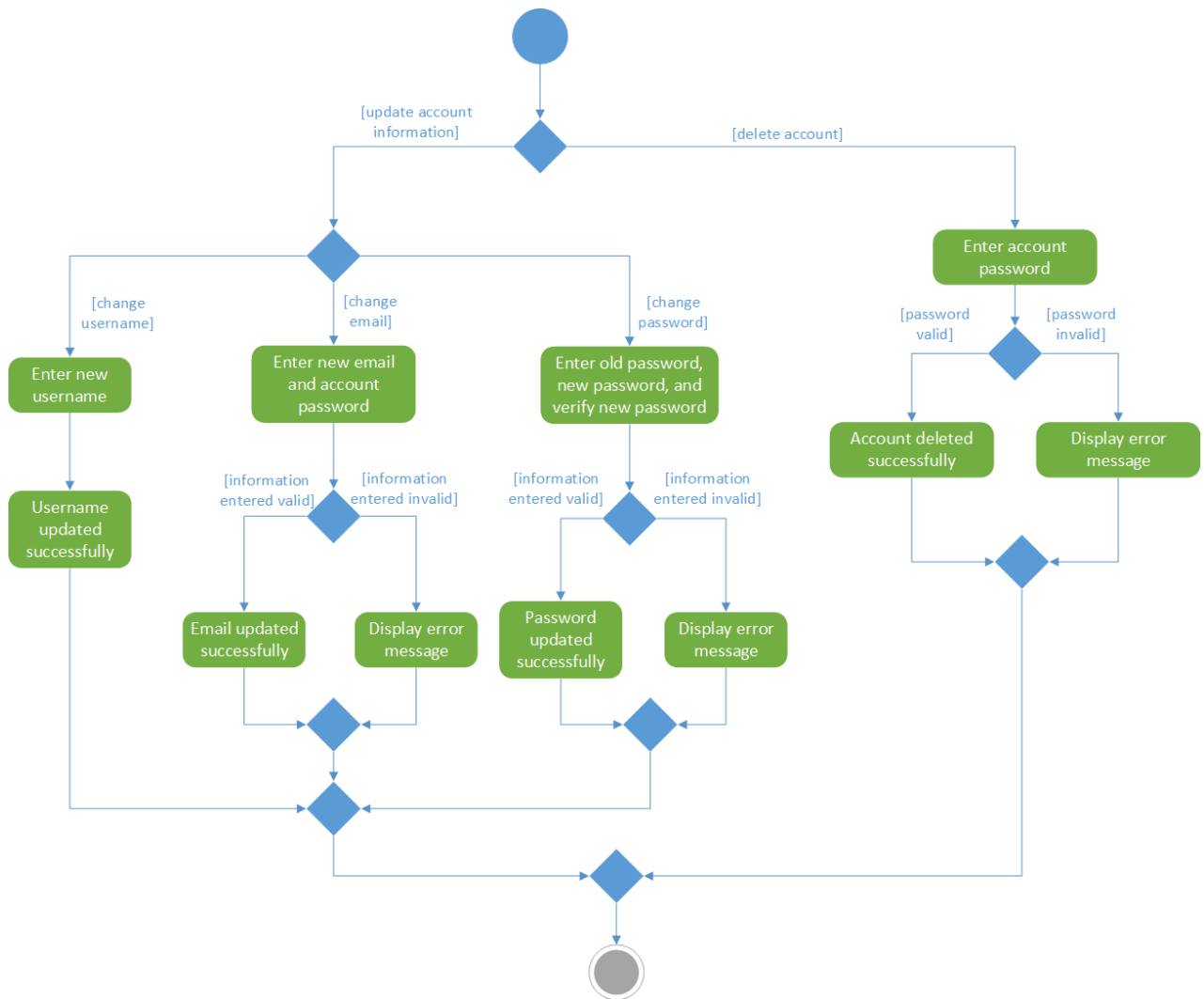


Figure 4.1.6.7: Activity Diagram - Profile Modification

Figure 4.1.6.7 shows the flow of profile modification. Users can modify or update their profiles after registration. Information that can be modified includes username, email, and password. Users are required to enter their account password if they wish to update their login email address to another. Besides, users have to enter their current password, new password, and new password verification if they want to update their password. If the information entered is valid and accurate, the information will be successfully updated. Furthermore, users can also choose to delete their account by entering the account password if they find that the account is no longer in use.

4.1.6.8 Video Playing Activity Diagram

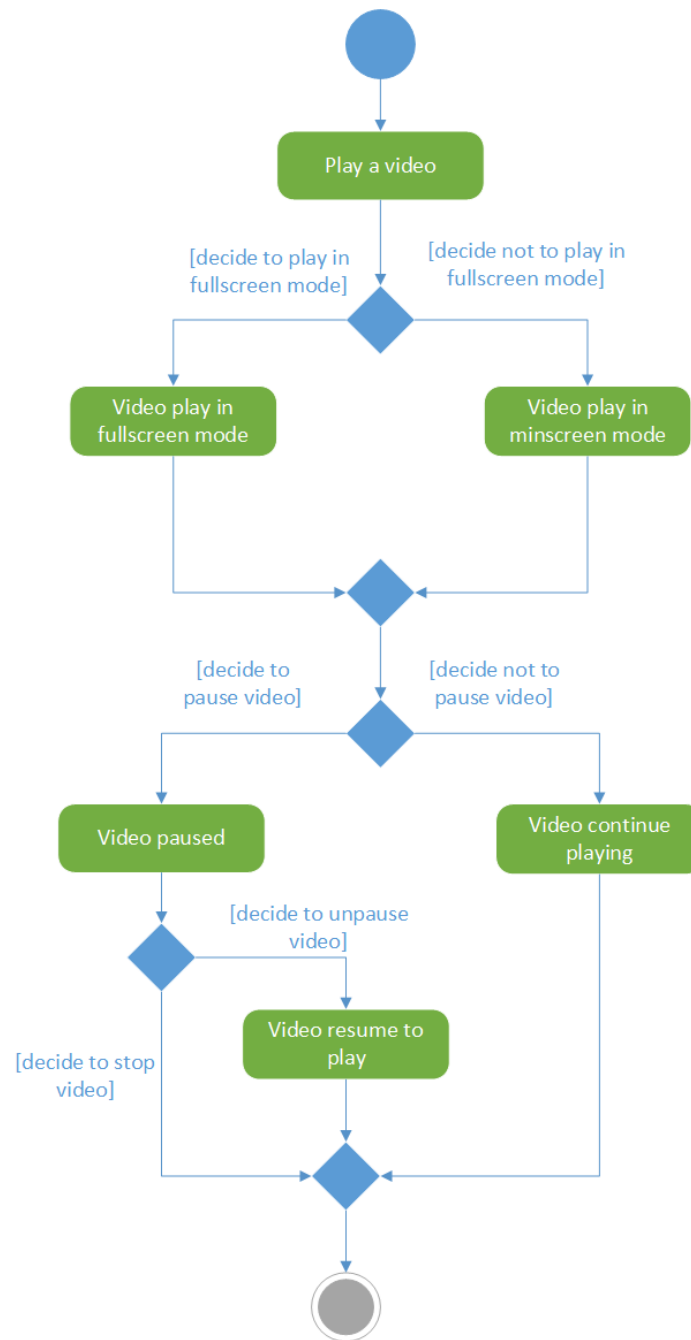


Figure 4.1.6.8: Activity Diagram - Video Playing

Figure 4.1.6.8 indicates the flow of video playing. While users play a video from the video list, they can always decide whether to play in fullscreen mode or minscreen mode. Besides, users can pause the video anytime and unpause it again if needed.

Chapter 5

System Implementation

5.1 Software Setup

5.1.1 Unity Installation

Step 1: Download Unity from <https://unity.com/download#how-get-started>

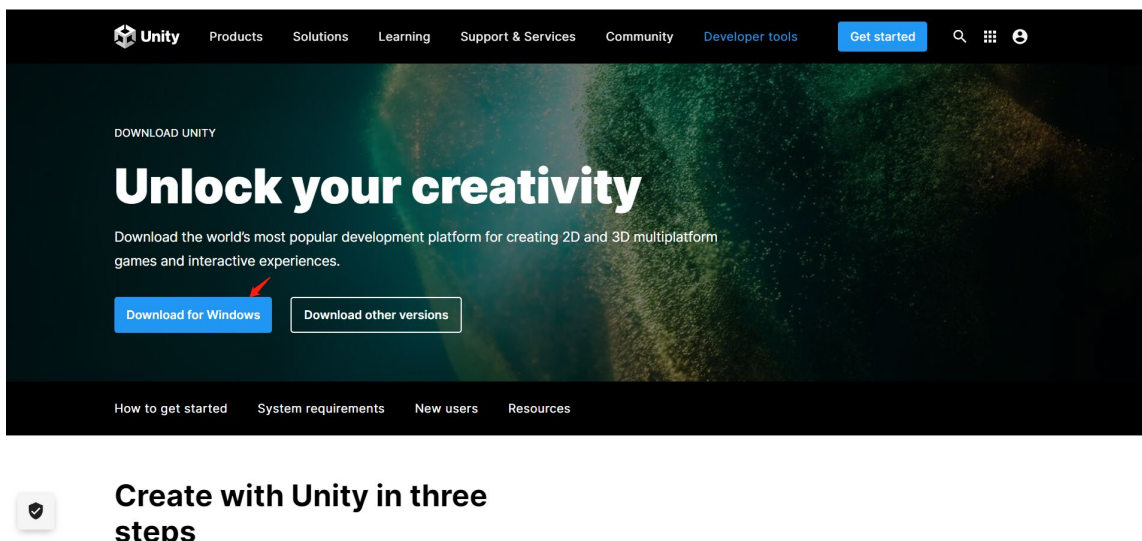


Figure 5.1.1-1: Download UnityHub

Step 2: Agree with License and Install UnityHub

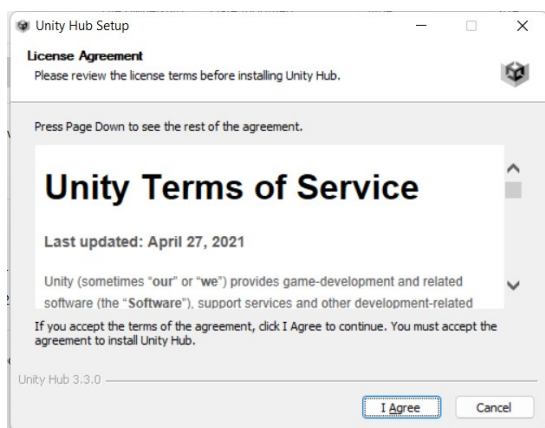


Figure 5.1.1-2: Agree with the License

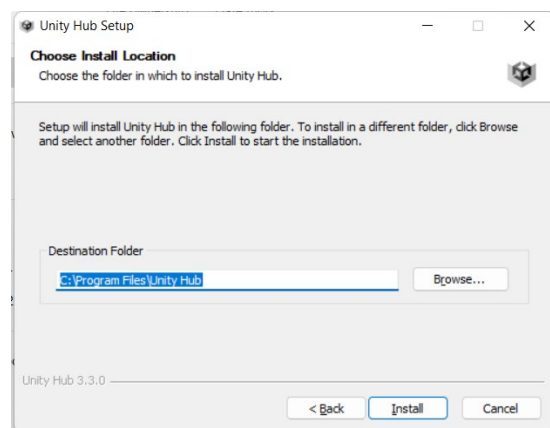


Figure 5.1.1-3: Install UnityHub

Step 3: Open UnityHub and Install Editor

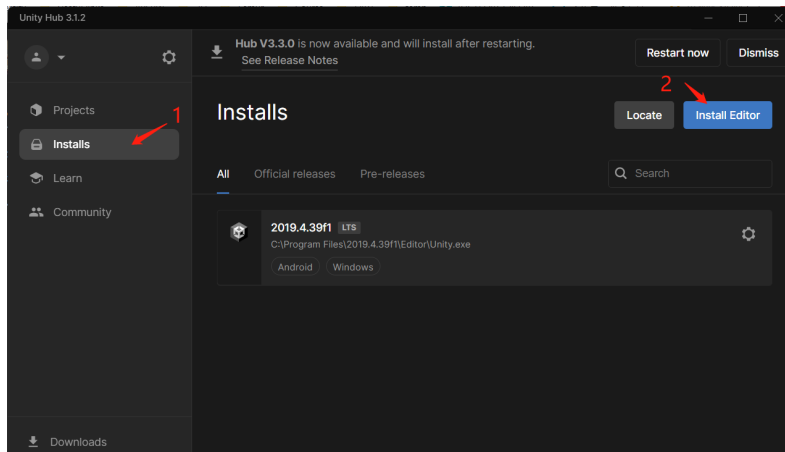


Figure 5.1.1-4: Select Editor Version to be Installed

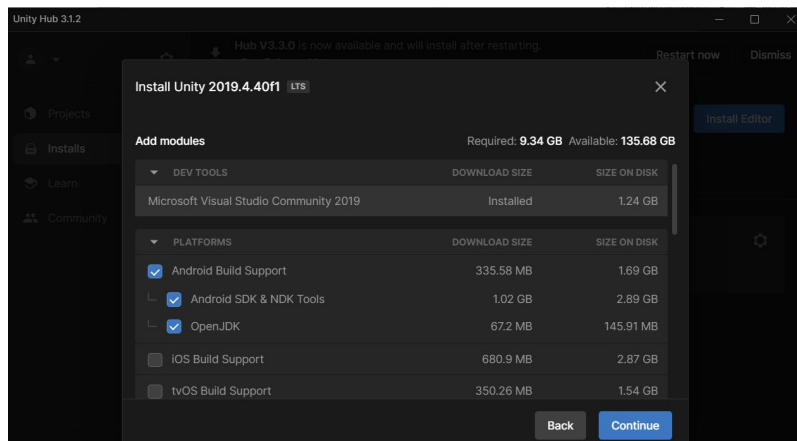


Figure 5.1.1-5: Select Module to be Installed

Step 4: License Activation

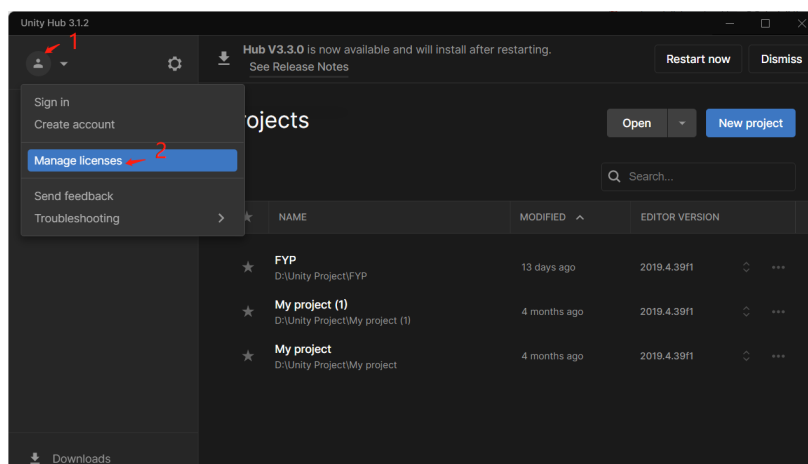


Figure 5.1.1-6: Select Manage Licenses

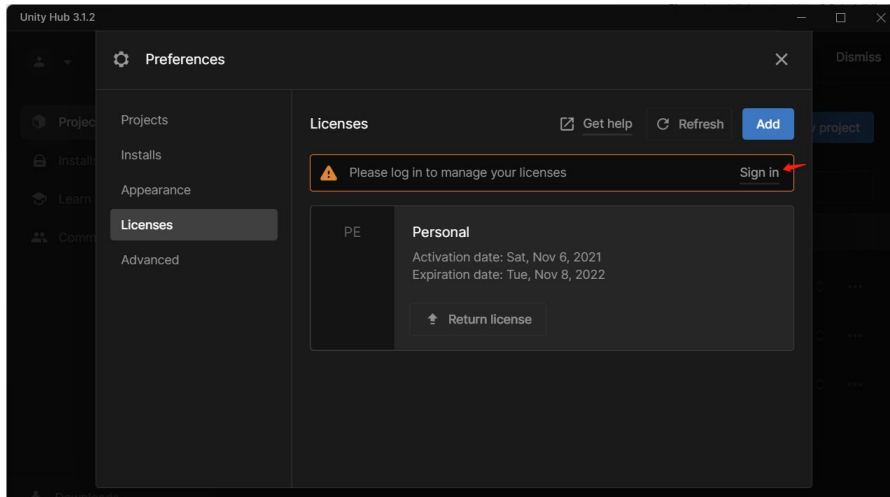


Figure 5.1.1-7: Sign In

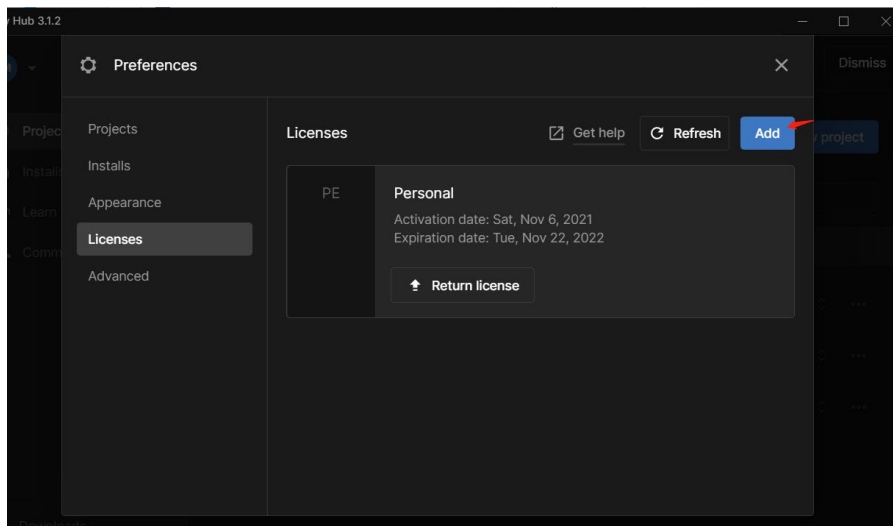


Figure 5.1.1-8: Add New License

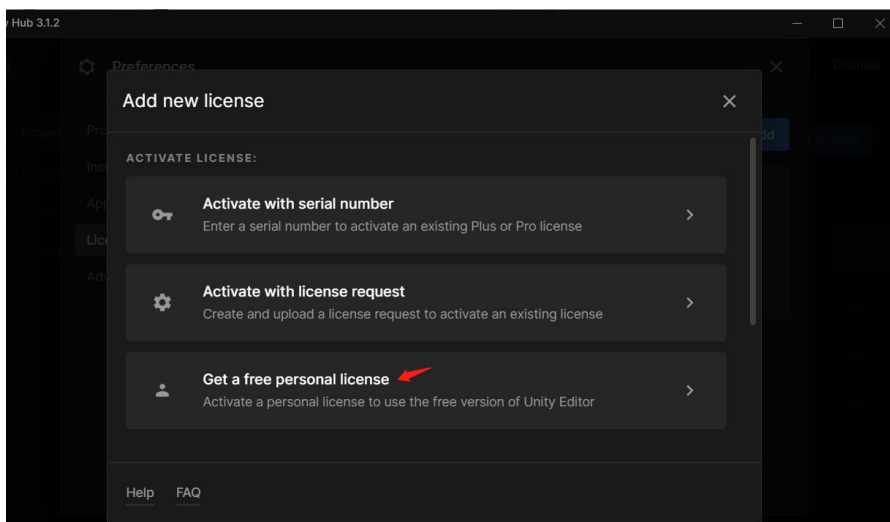


Figure 5.1.1-9: Activate Free Personal License

5.1.2 Visual Studio 2022 Installation

Step 1: Download Visual Studio Community 2022 from

<https://visualstudio.microsoft.com/vs/>

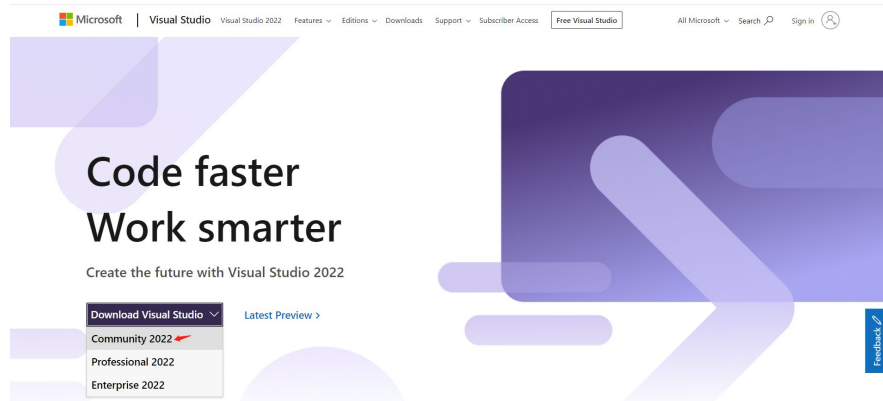


Figure 5.1.2-1: Download Visual Studio Community 2022

Step 2: Install Visual Studio Installer

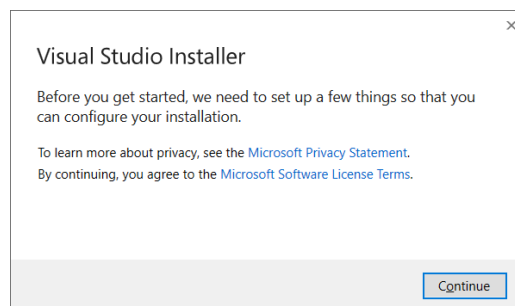


Figure 5.1.2-2: Select Continue and Agree with the License Terms

Step 3: Select and Install Workloads

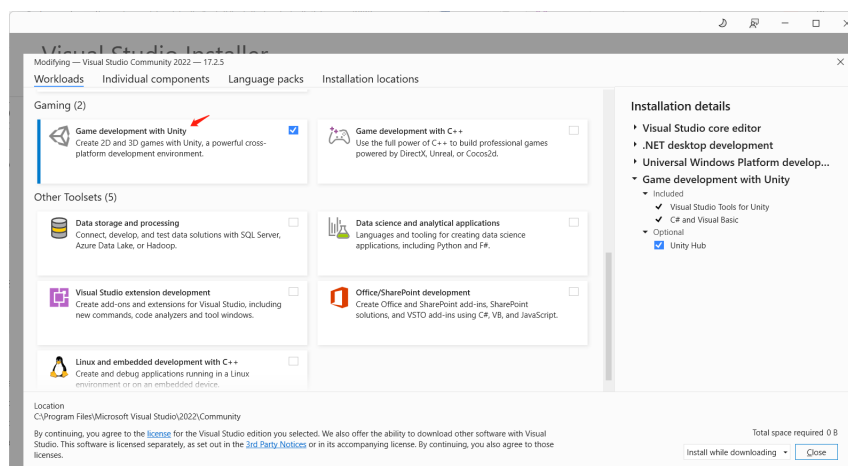


Figure 5.1.2-3: Choose the Workloads to be Installed

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Faculty of Information and Communication Technology (Kampar Campus), UTAR

5.1.3 Blender Installation

Step 1: Download Blender from <https://www.blender.org/download/>

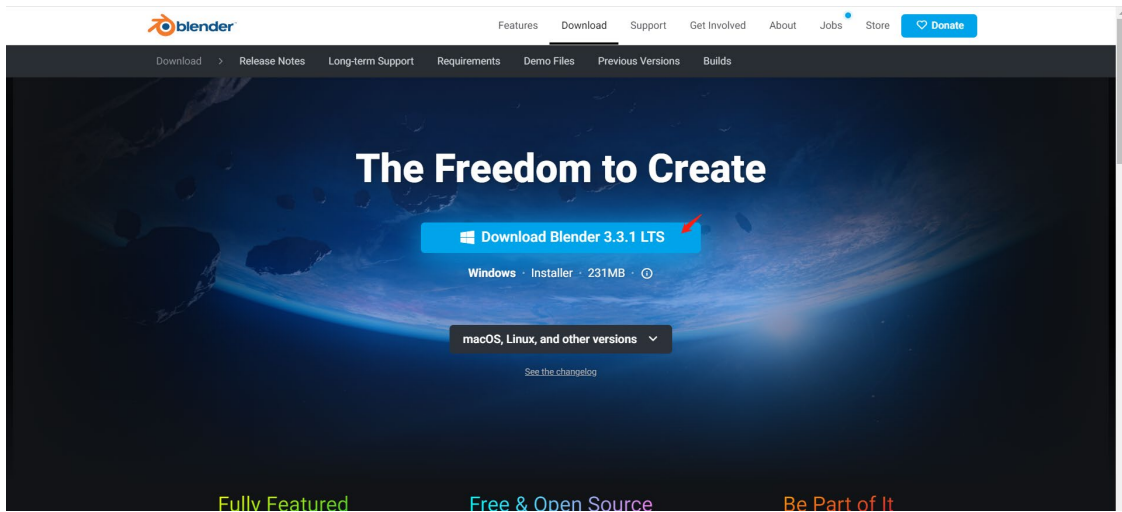


Figure 5.1.3-1: Download Blender

Step 2: Install Blender

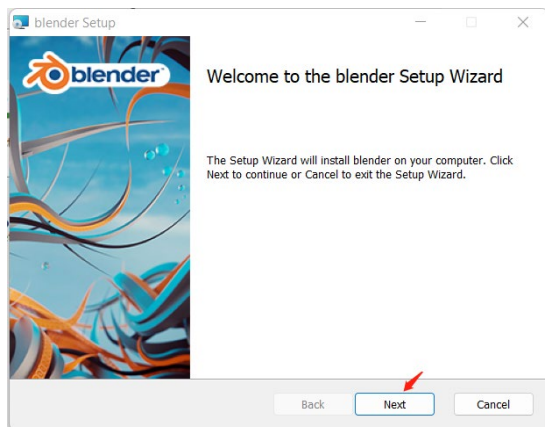


Figure 5.1.3-2: Click "Next"



Figure 5.1.3-3: Agree with the License Term

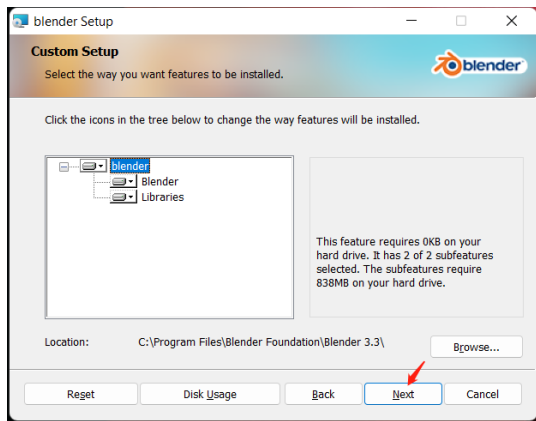


Figure 5.1.3-4: Browse Location for Blender Installation

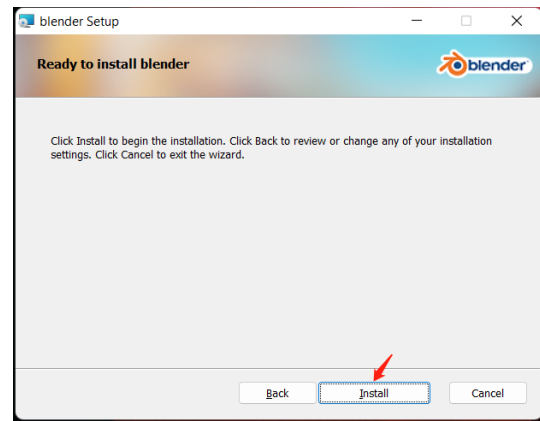


Figure 5.1.3-5: Install Blender

5.2 Setting and Configuration

5.2.1 Linkage between Software

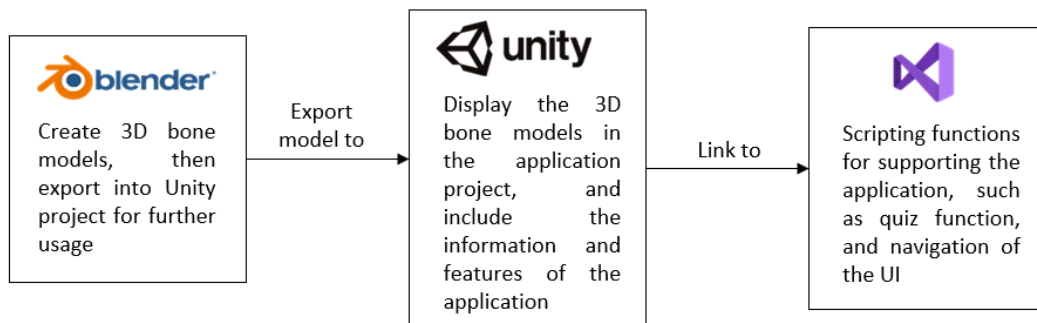


Figure 5.2.1-1: Relationship among the Software

After installing the software needed (Unity, Visual Studio 2022, Blender), Visual Studio 2022 is required to be linked with Unity for scripting the functions of the application, while Blender is used to create 3D bone model. The steps for linking the Unity and Visual Studio 2022 are as follow:

1. Open Unity Editor
2. Go to Edit > Preferences > External Tools
3. Set the External Script Editor as Visual Studio Community 2022

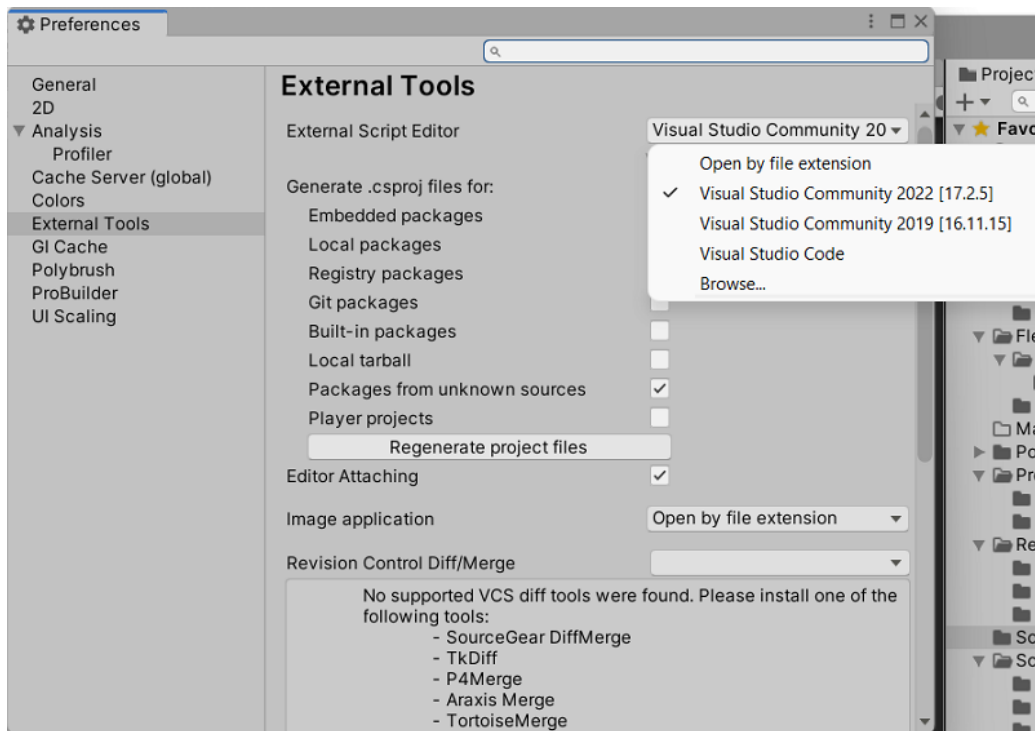


Figure 5.2.1-2: Linkage between Visual Studio and Unity

Before developing the application, 3D models of the bones should be prepared, where Blender had been chosen for creating the models in this project. After the models are created, the models are exported to the Unity project as .fbx file. The steps of exporting the models are as follow:

1. In Blender, go to File > Export > FBX
2. Select Unity project folder (In my case, I created and saved the models in a folder named “bones” in the “prefabs” folder of the Unity project. To only export the models, I ticked the checkbox of “Selected Objects” during exporting.)

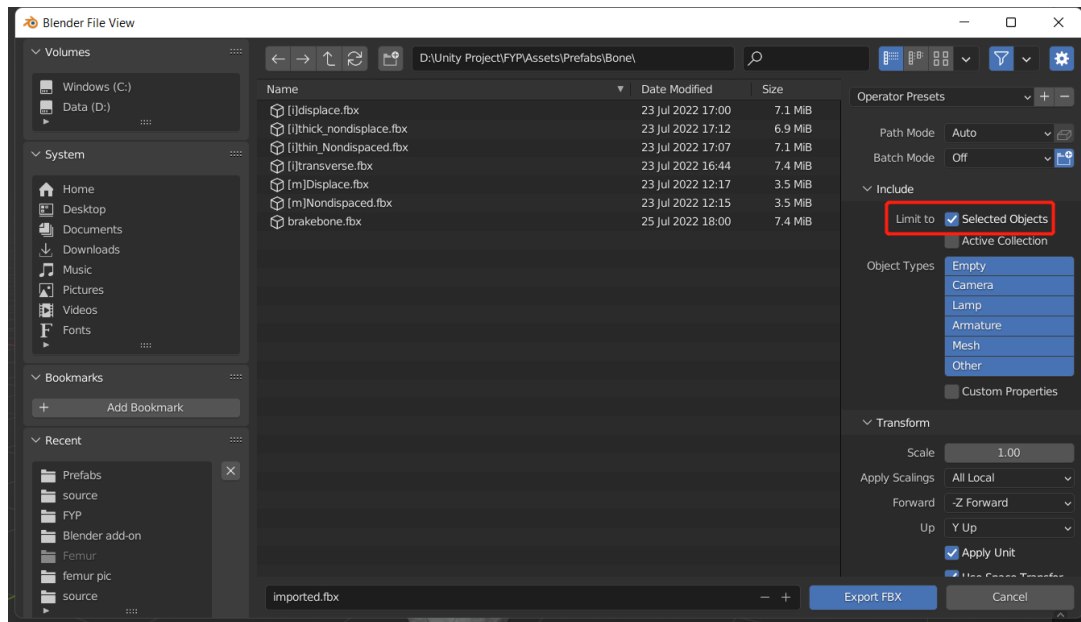


Figure 5.2.1-3: Export models from Blender to Unity

5.2.2 Device Simulator Setup

Besides, since this project is going to be developed on mobile platform, a device simulator is needed to test if the application is work in different mobile devices. The steps to install the device simulator in Unity are as follow:

1. Go to Window > Package Manager
2. Choose “Unity Registry”
3. Look for “Device Simulator”
4. Go to “Advanced > “Show preview packages” (if “Device Simulator” not found)
5. Install it, then the simulator option should appear in “Game”

(In my case, I already installed, hence, it shows “up to date” rather than “install”)

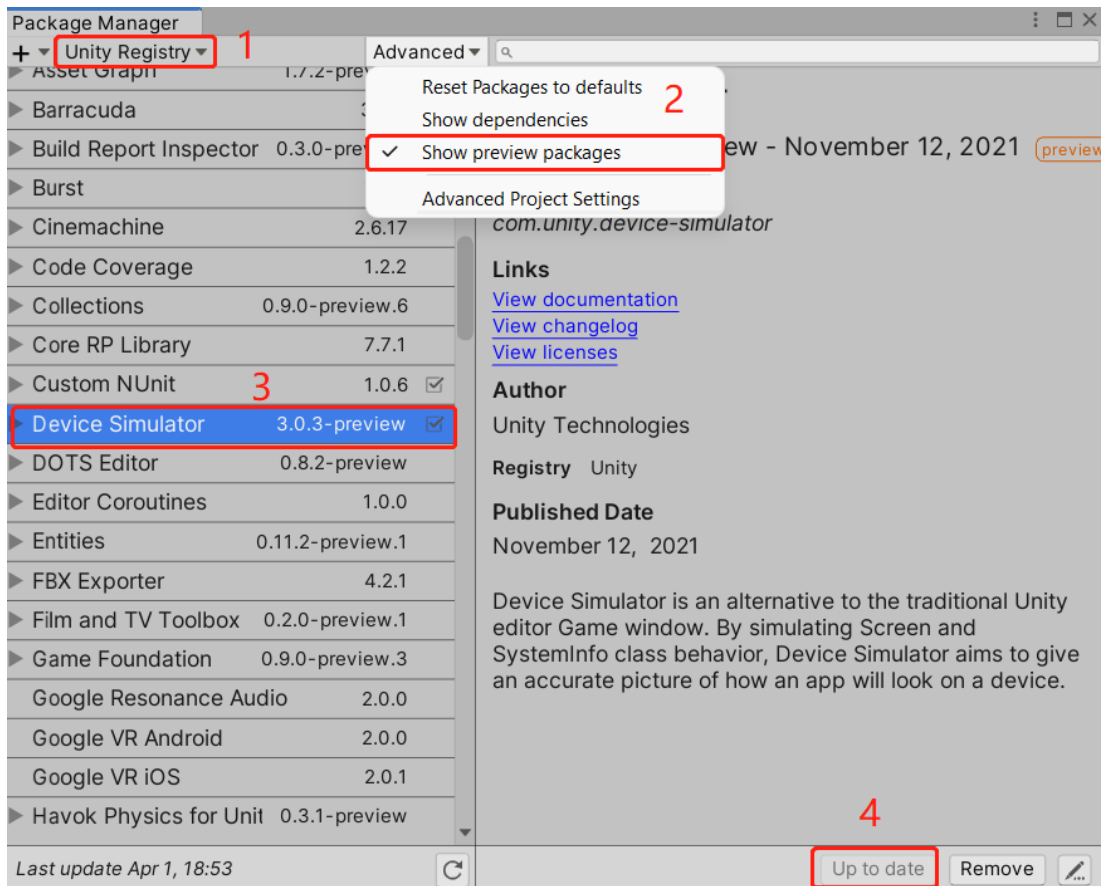


Figure 5.2.2-1: Installation of Device Simulator

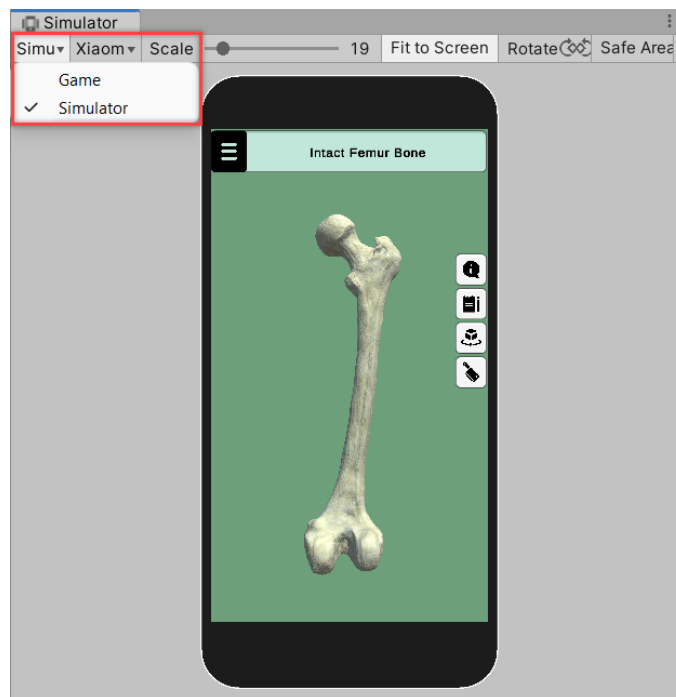


Figure 5.2.2-2: Simulator Option Appeared

5.2.3 PlayerPrefs Setup

Since this project will first save data in PlayerPrefs locally in the device, developer may have to preview the data save and ensure the data is stored accurately. PlayerPrefs is saved as the file format of .xml in different locations according to different development. This may cause inconvenience to preview data saved during the development process, therefore, there is another way to preview the data easily by installing a free plugin in Unity. PlayerPrefs Editor is a useful plugin that allows developer to add and delete PlayerPrefs by a simple click, and even edit the PlayerPrefs value. Besides, it also allows data preview data in a more convenient way with the features of sorting, watch data changes during runtime, and data refresh. Following are the steps to install and use the plugin:

1. Go to Windows > Asset Stores
2. Search “PlayerPrefs Editor” through the search bar and install the one that had been circled with red rectangle.
3. PlayerPrefs Editor then can be found in Tools > BG Tools > PlayerPrefs Editor
4. Then, there will be a small window appear after clicking on the PlayerPrefs Editor.

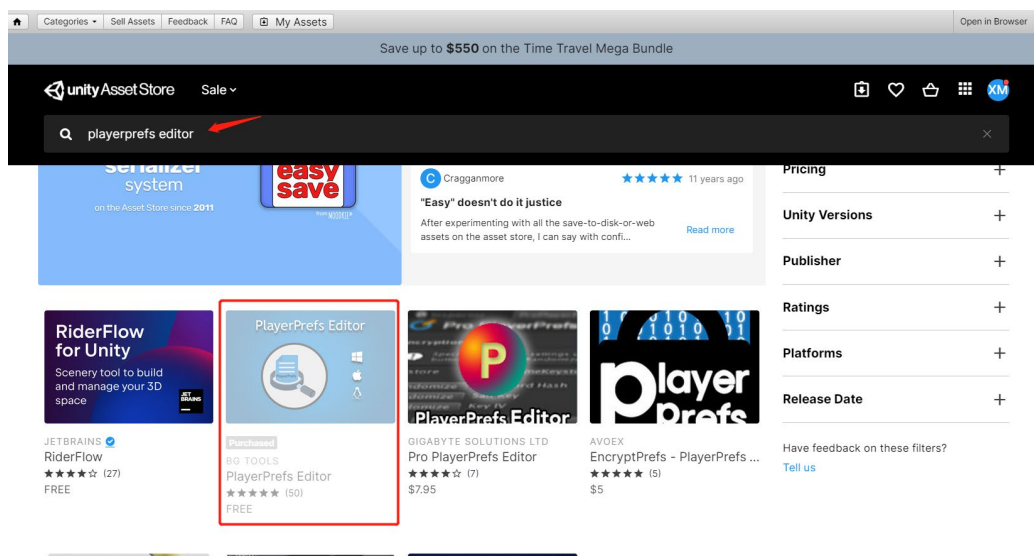


Figure 5.2.3-1: Search and Install PlayerPrefs Editor

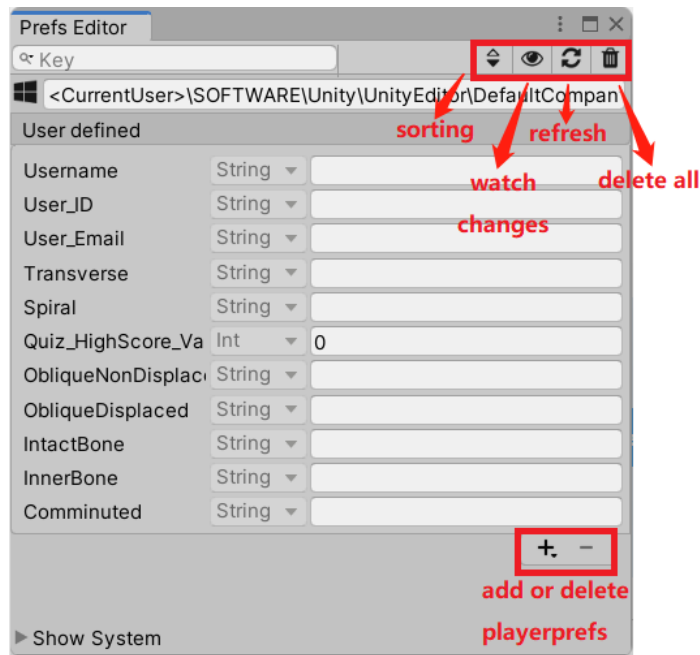


Figure 5.2.3-2: PlayerPrefs Editor Window

5.2.4 Firebase Setup

In this project, Firebase plays an important role for users to store data on the cloud. Below are steps to setup the Firebase for this project:

1. Go to Firebase console: <https://console.firebase.google.com/u/0/>
2. Add new project for Firebase.
3. Give a name for the Firebase project.
4. Uncheck Google Analytics and create a project.
5. Click into the created project, select “Unity” to add Firebase to the Unity app.
6. In Unity project, go to Edit > Project Settings
7. Select “Player” from the menu, scroll down and get “Package Name” from “Identification”.
8. Back to Firebase project in the browser, paste the package name to register an Android app.
9. Then, move to the next step to download the “google-services.json” file and put it under “Assets” of the Unity project.

10. Next, follow the steps to download and unzip the Firebase Unity SDK file, and import those needed packages into the Unity. For instance, Firebase Auth and Firebase Database are the only 2 packages used in this project.
11. Create a script to initialise the Firebase. The important code to test the availability of Firebase is in Awake() method. Once it is available, it will call the method of InitializeFirebase().
12. Attach it to the GameObject of “DBManager” in Unity project.
[It is not necessary to be named as “DBManager”]
13. Run the project, the information in InitializeFirebase() shown in the console, which means it works and done setting up the Firebase in Unity project.

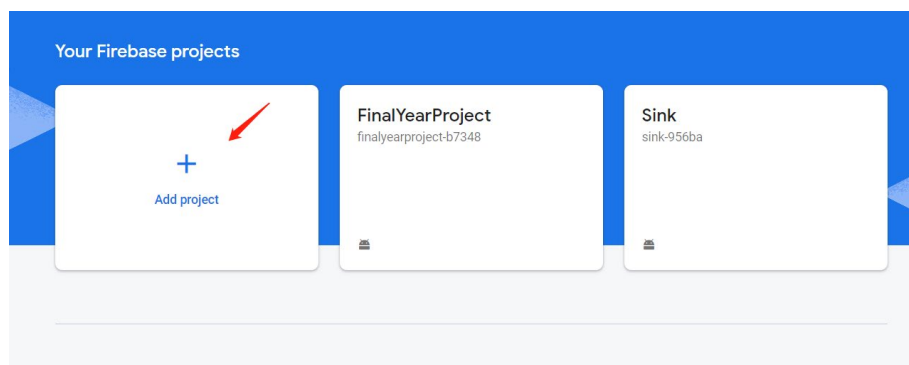


Figure 5.2.4-1: Create A New Firebase Project

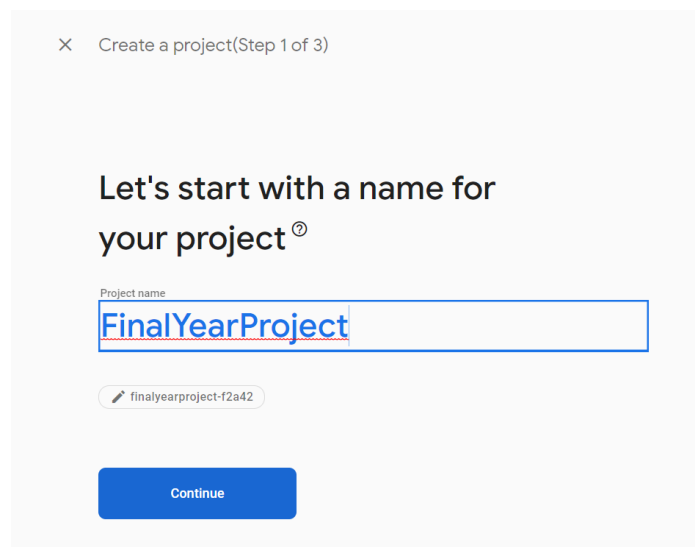


Figure 5.2.4-2: Name the Firebase Project

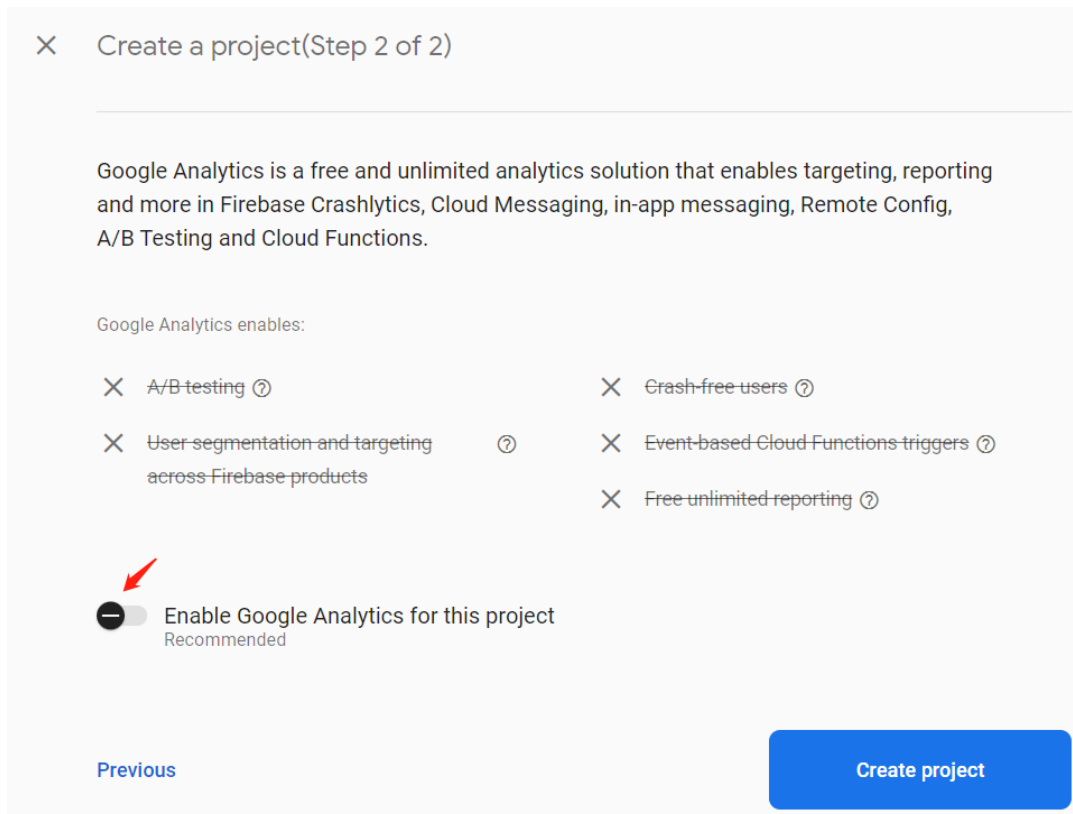


Figure 5.2.4-3: Uncheck Google Analytics and Create Project

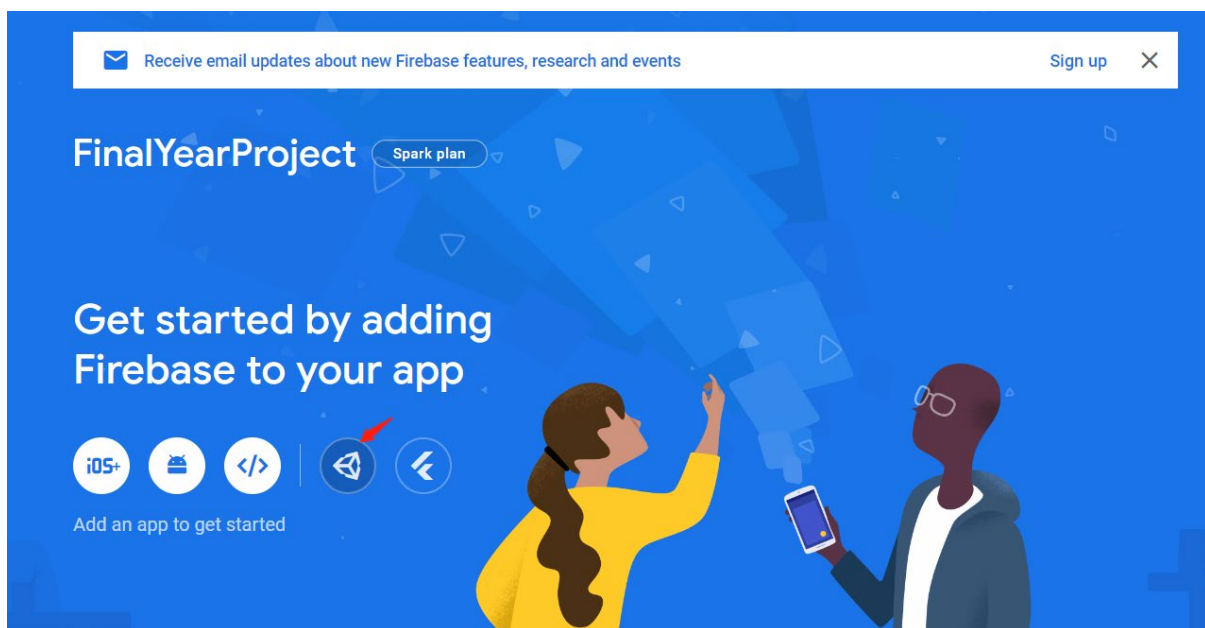


Figure 5.2.4-4: Create Unity App

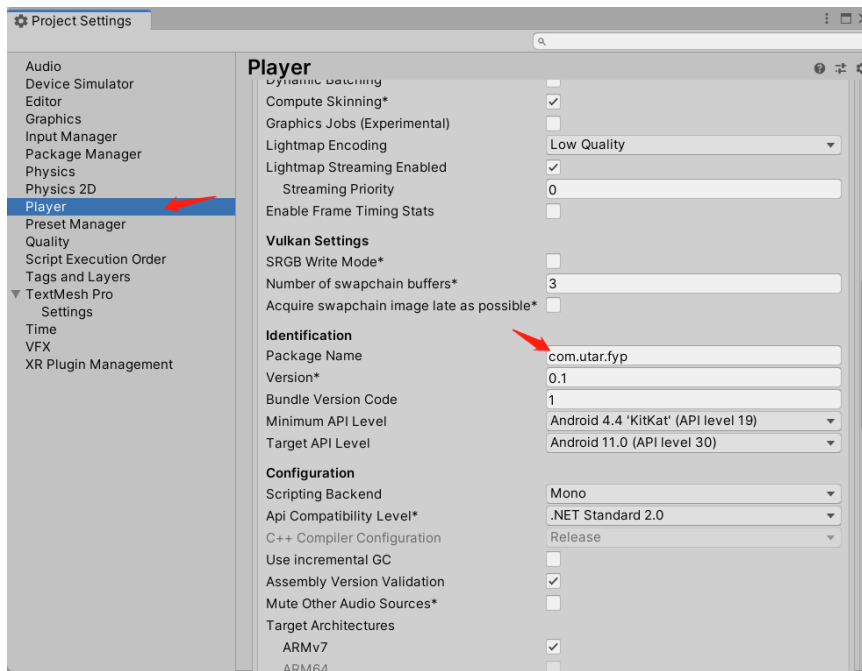


Figure 5.2.4-5: Get Package Name from Unity Project

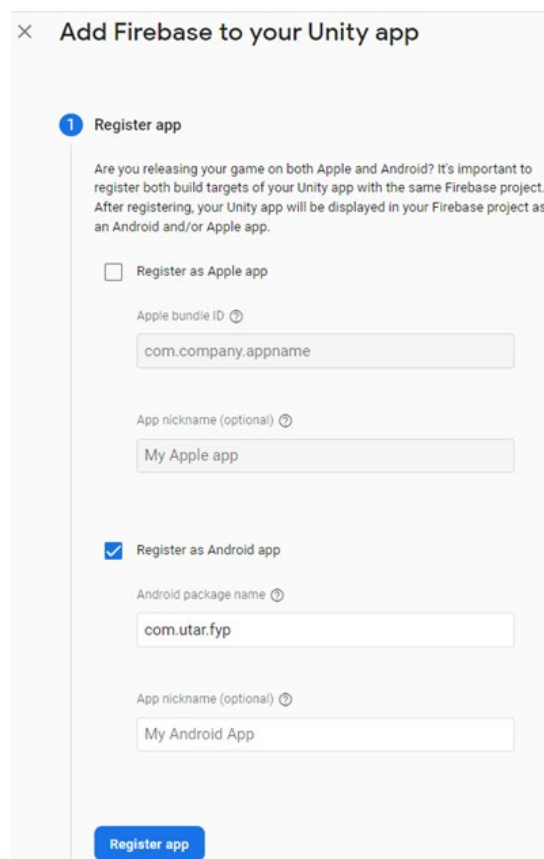


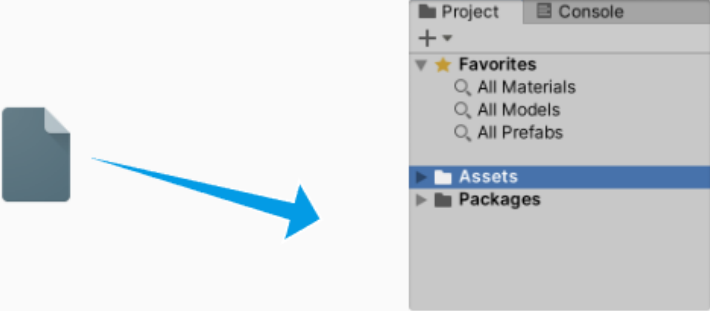
Figure 5.2.4-6: Register App with the Same Package Name

2 Download config file

[Download google-services.json](#)

Open the Project window of your Unity project, then move your downloaded Firebase config file into the Assets folder.

Note: You can place the Firebase config file anywhere within the Assets folder.



The diagram illustrates the process of moving a downloaded file into the Unity Project window. On the left, there is a dark grey document icon representing the downloaded file. A blue arrow points from this icon to the right, where a screenshot of the Unity Project window is shown. The Project window has a 'Project' tab and a 'Console' tab. Under the 'Project' tab, there is a '+' icon and a 'Favorites' section with three items: 'All Materials', 'All Models', and 'All Prefabs'. Below the Favorites, the 'Assets' folder is highlighted with a blue bar, and the 'Packages' folder is visible below it.

[Next](#)

Figure 5.2.4-7: Download Config File and Put under Assets Folder of Unity Project

3 Add Firebase SDK

[Download Firebase Unity SDK \(Zip\)](#)

1. Unzip the downloaded SDK somewhere convenient.
2. In your open Unity project, navigate to Assets > Import Package > Custom Package.
3. From the unzipped SDK, select to import the SDKs for the desired [Firebase products](#).
4. In the *Import Unity Package* window, click **Import**.

[Previous](#) [Next](#)

Figure 5.2.4-8: Download Firebase SDK and Import to Unity Project

```

void Awake()
{
    //Check that all of the necessary dependencies for Firebase are present on the system
    FirebaseApp.CheckAndFixDependenciesAsync().ContinueWith(task =>
    {
        dependencyStatus = task.Result;
        if (dependencyStatus == DependencyStatus.Available)
        {
            //If they are available Initialize Firebase
            InitializeFirebase();
        }
        else
        {
            Debug.LogError("Could not resolve all Firebase dependencies: " + dependencyStatus);
        }
    });
}
1 reference
private void InitializeFirebase()
{
    Debug.Log("Setting up Firebase Auth");
    //Set the authentication instance object
    auth = FirebaseAuth.DefaultInstance;
    auth.StateChanged += AuthStateChanged;
    AuthStateChanged(this, null);
    DBReference = FirebaseDatabase.DefaultInstance.RootReference;
}

```

Figure 5.2.4-9: Create Script to Initialise Firebase

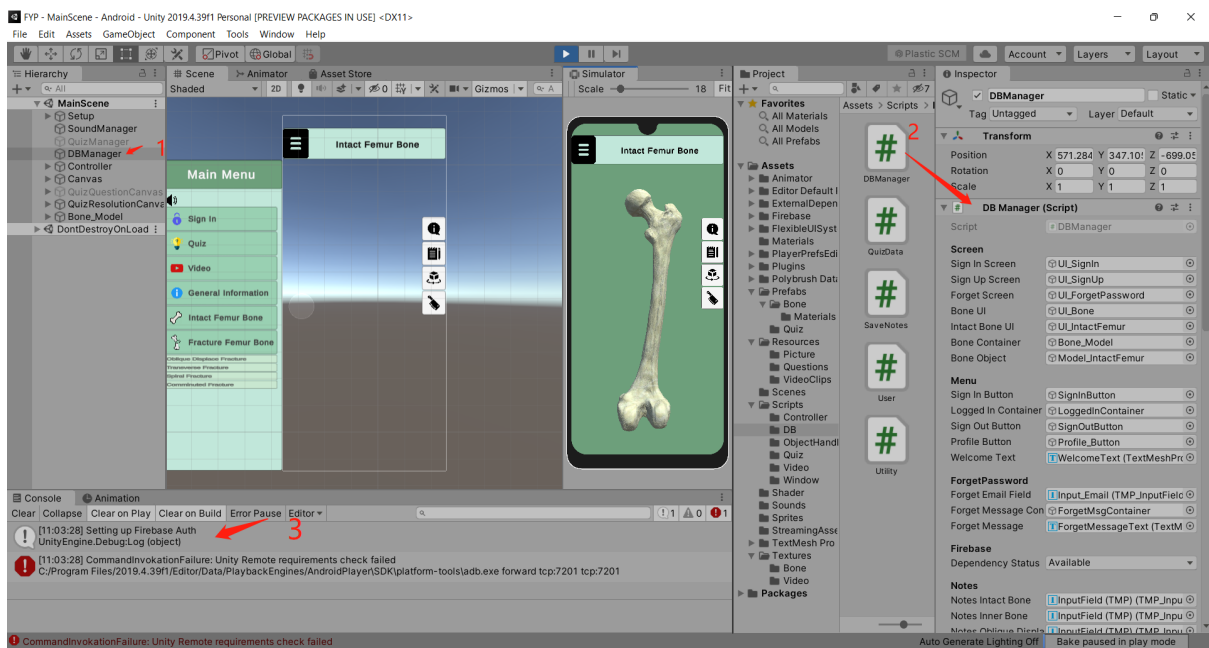


Figure 5.2.4-10: Firebase Initialised Successfully

5.3 System Operation (with Screenshot)

5.3.1 Splash Screen and Sign In

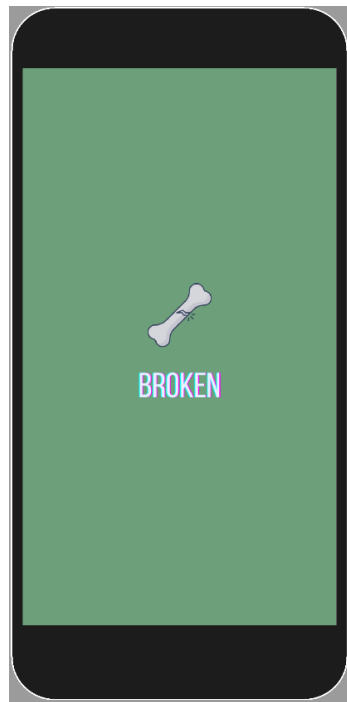


Figure 5.3.1-1: Splash Screen

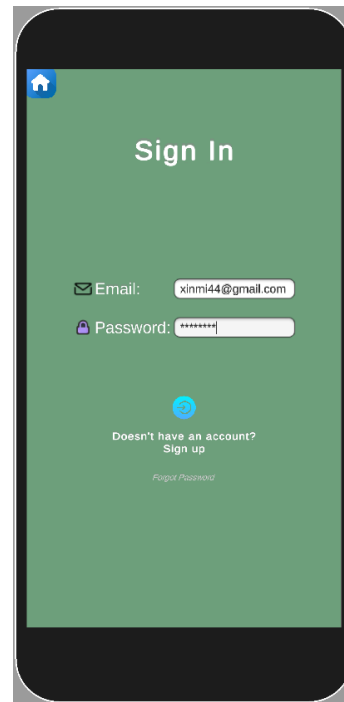


Figure 5.3.1-2: Sign In Page

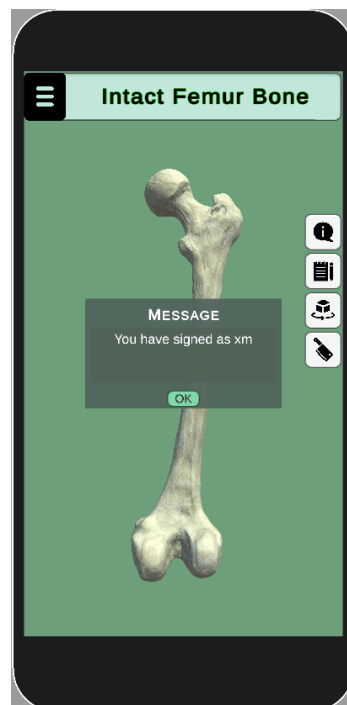


Figure 5.3.1-3: Sign In
Successfully (1)

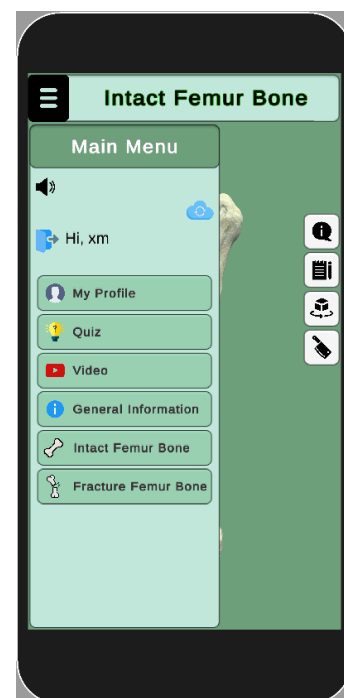


Figure 5.3.1-4: Sign In
Successfully (2)

Figure 5.3.1-1 represents the splash screen of the app. The main screen, which is the first screen after the splash screen is the “Intact Femur Bone” screen (as in Figure 5.3.1-3). Users are not necessary to sign in to use this app, it is just for the purpose of saving data into a cloud, such as notes and quiz scores. There is a sign in button residing in the main menu, if users wish to sign in, the sign in screen will show to users (as in Figure 5.3.1-2). In the sign in screen, users can also choose to register a new account or reset the password if they forgot their password. After signing in, the main “Intact Femur Bone” screen will show users a temporary message “Signed in as username”. Figure 5.3.1-4 shows that the username, sign out button, and sync button are then displayed in the main menu if the user has successfully signed in.

5.3.2 Sign Up



Figure 5.3.2-1: Sign Up Page

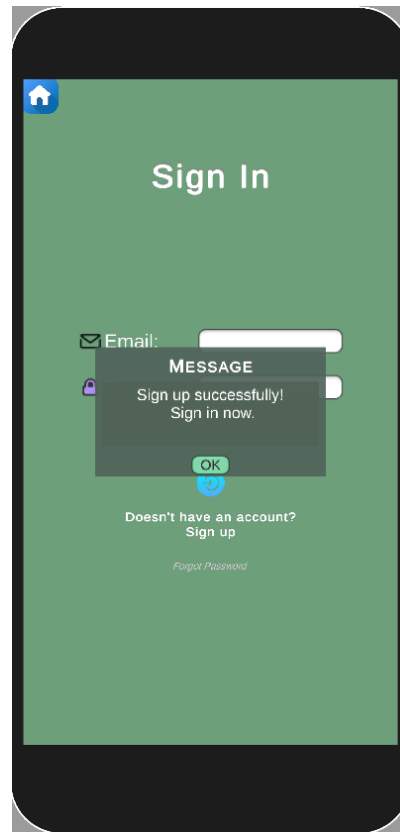


Figure 5.3.2-2: Sign Up Successfully

If users do not have an account, they can sign up for a new account if they want. Figure 5.3.2-1 indicates the sign up screen. An account will be created successfully if users enter the correct format of email as well as both the password and confirm password are matching. As Figure 5.3.2-2 shows, if the account has been created successfully, there will be a message “Sign up successfully! Sign in now.” prompt out, and direct the users back to the sign in screen to sign in.

5.3.3 Profile

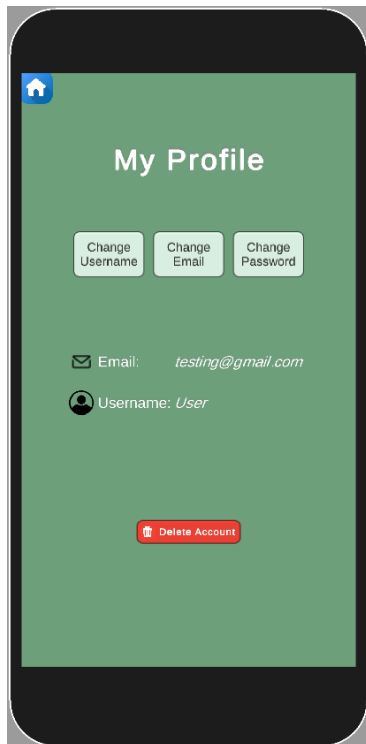


Figure 5.3.3-1: Profile Page

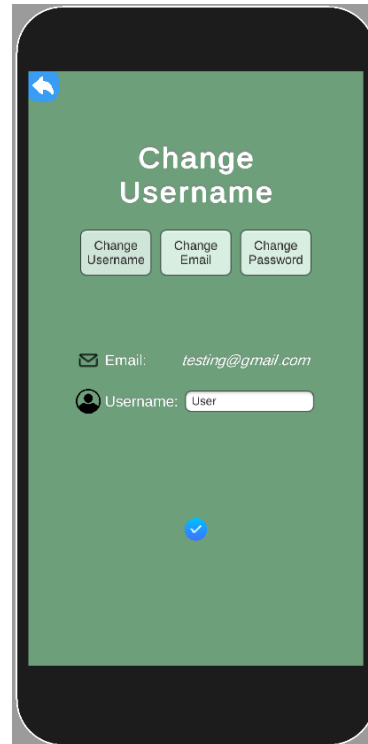


Figure 5.3.3-2: Change Username Page

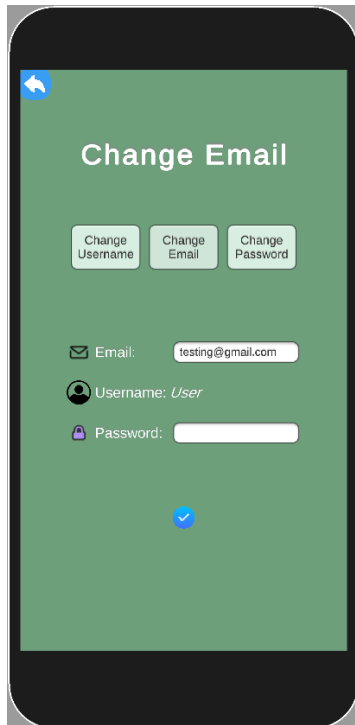


Figure 5.3.3-3: Change Email Page

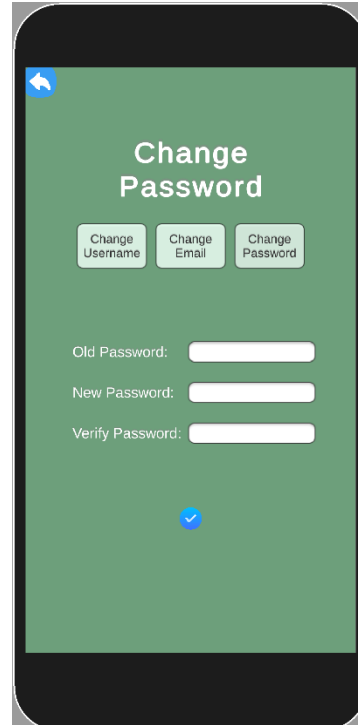


Figure 5.3.3-4: Change Password Page

If users have signed into their accounts, they are allowed to modify their profile. Figure 5.3.3-1 represents the user profile. Users have the right to delete their accounts by clicking the “Delete Account” button. If they wish to delete their account, they are required to re-enter their password for verification. Besides, users can click the corresponding button to change their username, email, and password if they want. The pages for editing the profile are shown in Figure 5.3.3-2, Figure 5.3.3-3, and Figure 5.3.3-4.

5.3.4 Intact Femur Bone

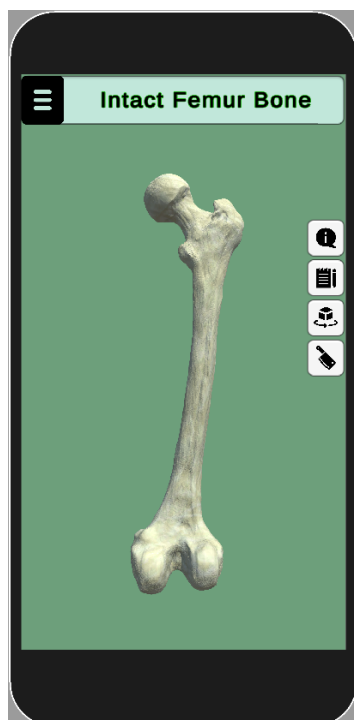


Figure 5.3.4-1: Intact Femur Bone - Page

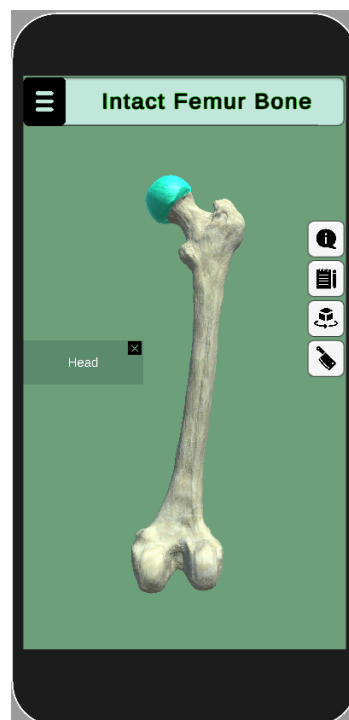


Figure 5.3.4-2: Intact Femur Bone - Labelling

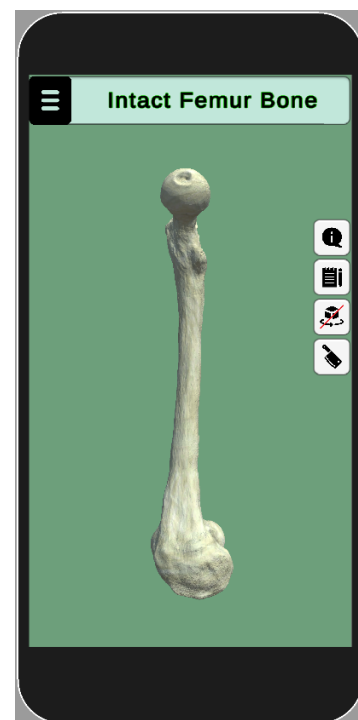


Figure 5.3.4-3: Intact Femur Bone - Rotation

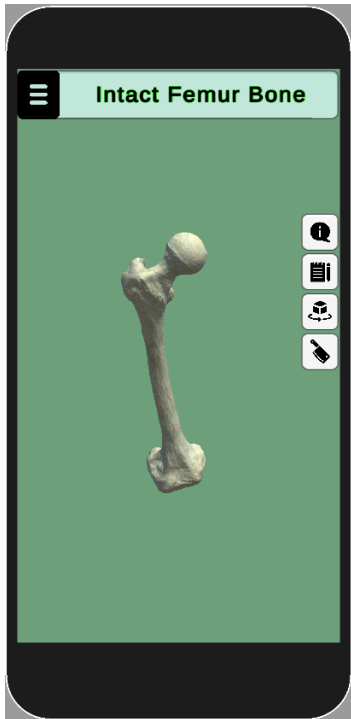


Figure 5.3.4-4: Intact Femur Bone - Scaling

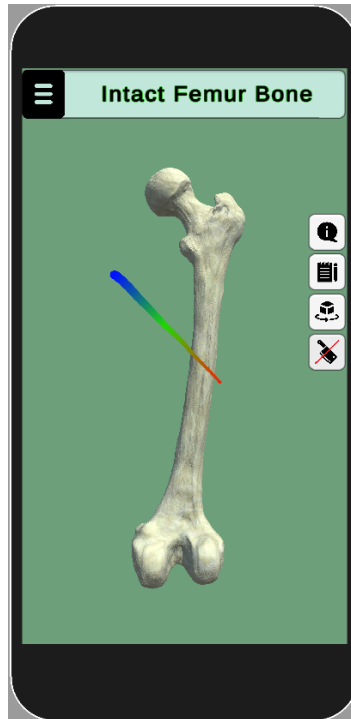


Figure 5.3.4-5: Cut Effect

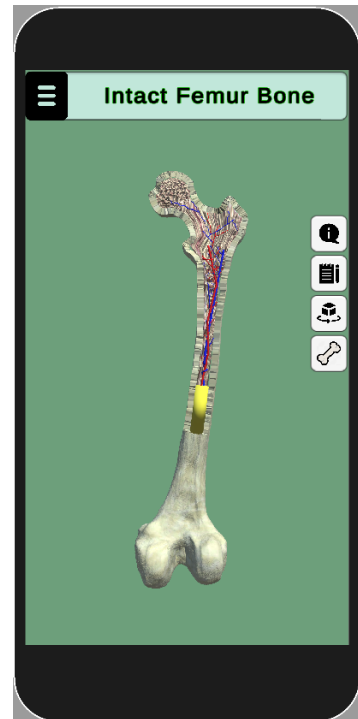


Figure 5.3.4-6: Inner Part - Page



Figure 5.3.4-7: Inner Part - Labelling



Figure 5.3.4-8: Inner Part - Rotation

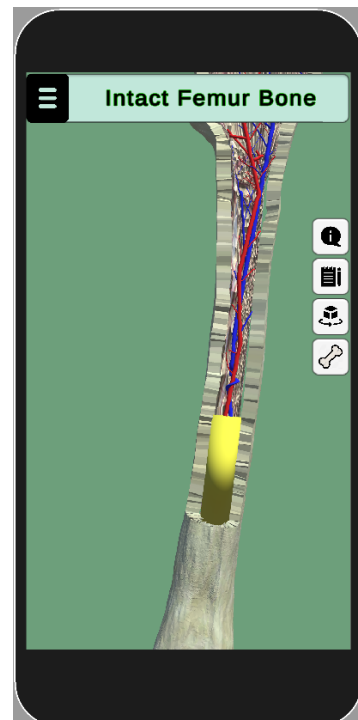


Figure 5.3.4-9: Inner Part - Scaling



Figure 5.3.4-10: Intact Femur Bone - Info and Notes

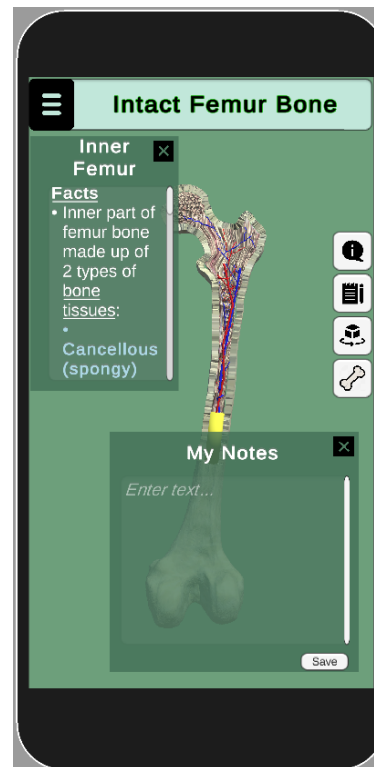


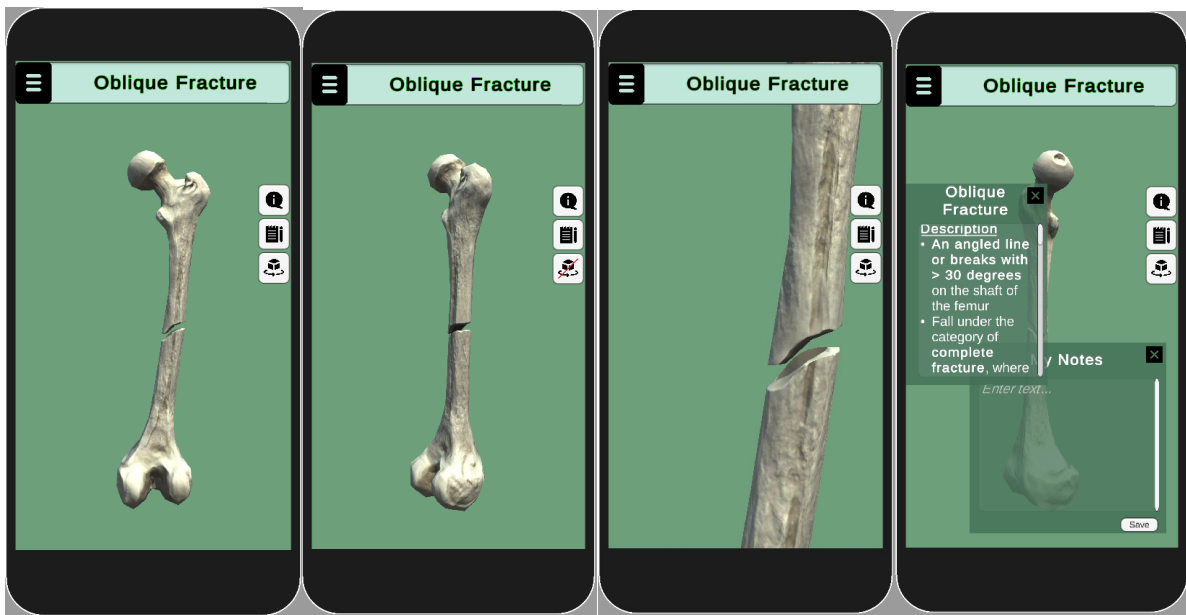
Figure 5.3.4-11: Inner Part - Info and Notes

The figures above show features included for learning the intact femur bone. As in Figure 5.3.4-2 and Figure 5.3.4-7, there is a label displayed when users touch the part of the bone. Users can also scale the bone model if they want as shown in Figure 5.3.4-4 and Figure 5.3.4-9. Besides, different features are available when navigating on different buttons on the right side. The four buttons represent information, notes, rotate, and cut accordingly for intact femur bone. In contrast, the fourth button for the inner part of the femur bone allows users to turn back to the intact femur bone model. On the other hand, there will be an effect and sound if users cut the intact femur bone by enabling the feature with the fourth button on the intact femur bone page and swiping through the bone. Figure 5.3.4f will then show to users after swiping, which is with the inner part of femur bone. Furthermore, when users click on the “information” or “notes” button, there will be a pop-up window displayed to users, which has illustrated in Figure 5.3.4-10 and Figure 5.3.4-11. Users can read the information and make their own notes. Lastly, users can click on the “rotate” button to rotate the bone model (Figure 5.3.4-3 and Figure 5.3.4-8).

5.3.5 Fractured Bone on Femoral Shaft

The models included in the fractured bones are similar to the intact femur bone, the minor difference is only the absence of the cut feature. Below are the figures illustrating each type of fracture, including oblique fracture, transverse fracture, spiral fracture, and comminuted fracture.

5.3.5.1 Oblique Fracture



*Figure 5.3.5.1-1:
Oblique Fracture -
Page*

*Figure 5.3.5.1-2:
Oblique Fracture
- Rotation*

*Figure 5.3.5.1-3:
Oblique Fracture
- Scaling*

*Figure 5.3.5.1-4:
Oblique Fracture -
Info and Notes*

5.3.5.2 Transverse Fracture

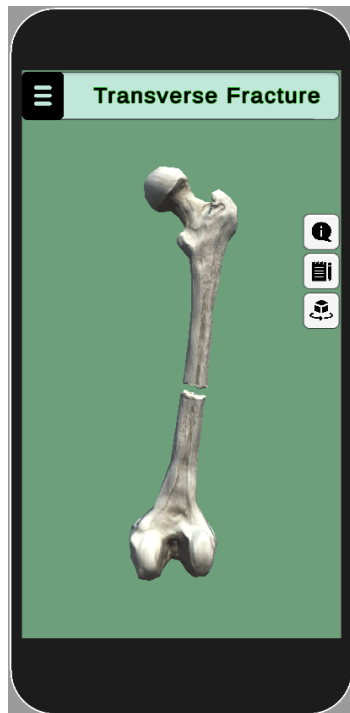


Figure 5.3.5.2-1: Transverse Fracture - Page



Figure 5.3.5.2-2: Transverse Fracture - Rotation



Figure 5.3.5.2-3: Transverse Fracture - Scaling

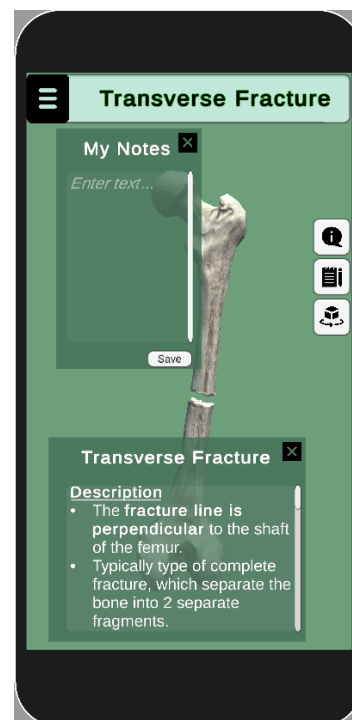


Figure 5.3.5.2-4: Transverse Fracture - Info and Notes

5.3.5.3 Spiral Fracture

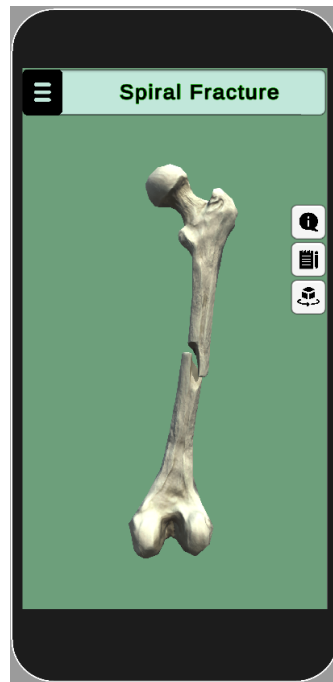


Figure 5.3.5.3-1: Spiral Fracture - Page



Figure 5.3.5.3-2: Spiral Fracture - Rotation

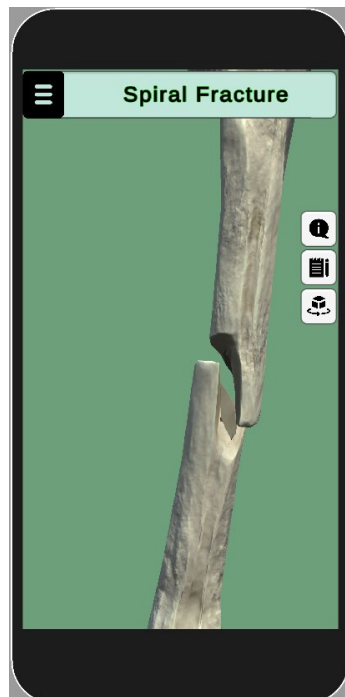


Figure 5.3.5.3-3: Spiral Fracture - Scaling

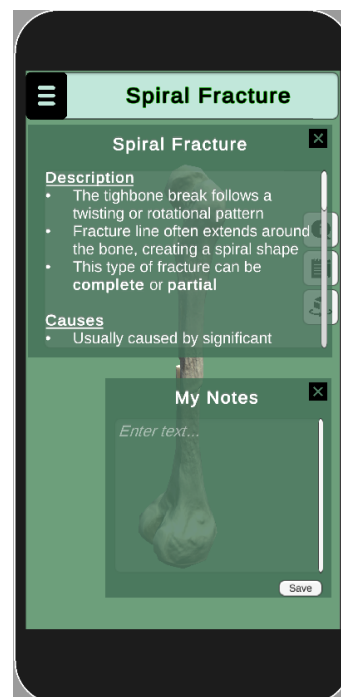


Figure 5.3.5.3-4: Spiral Fracture - Info and Notes

5.3.5.4 Comminuted Fracture

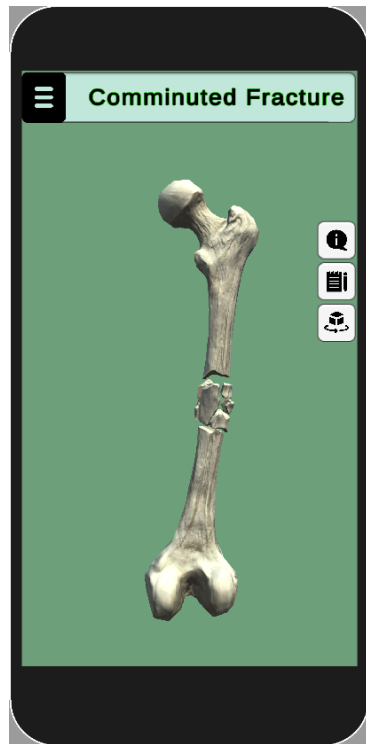


Figure 5.3.5.4-1: Comminuted Fracture - Page



Figure 5.3.5.4-2: Comminuted Fracture - Rotation

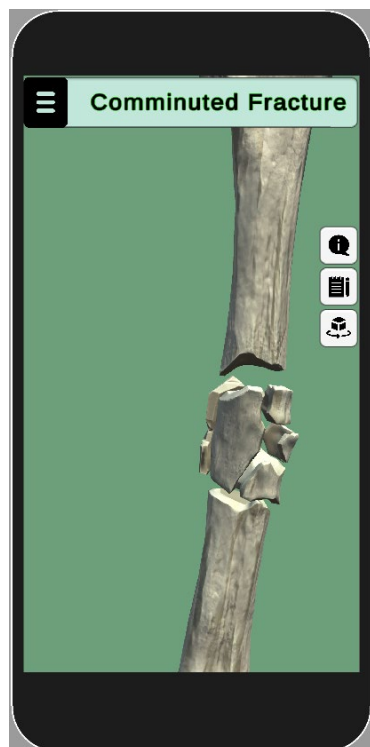


Figure 5.3.5.4-3: Comminuted Fracture - Scaling

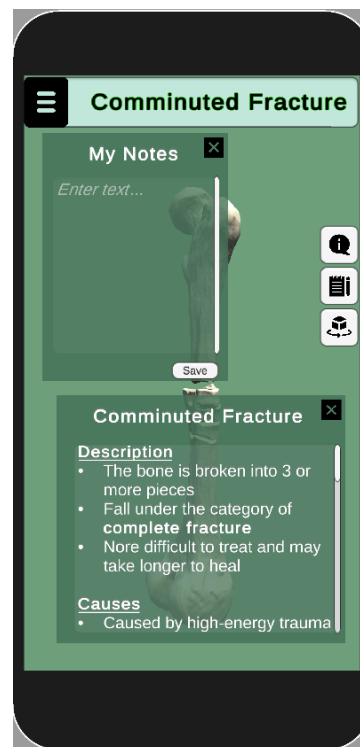


Figure 5.3.5.4-4: Comminuted Fracture - Info and Notes

5.3.6 General Information

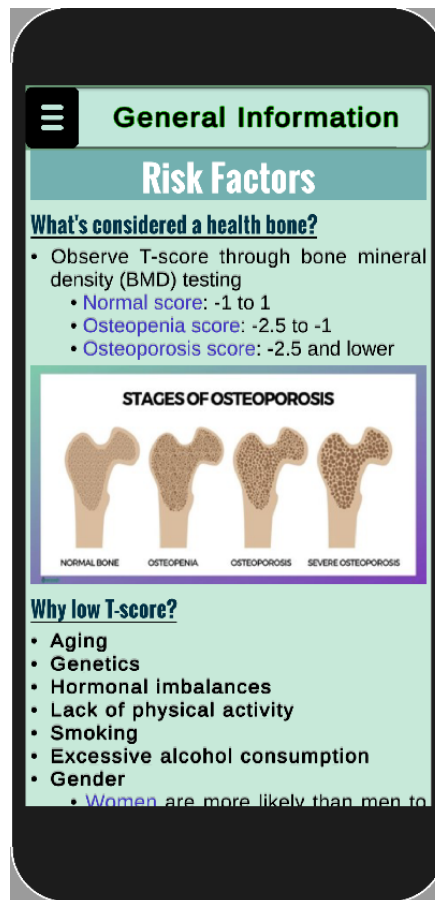
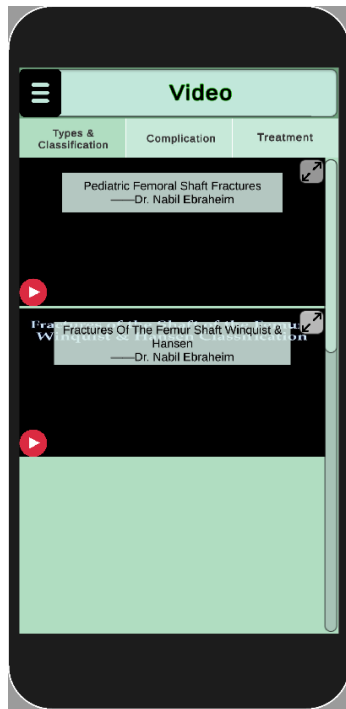


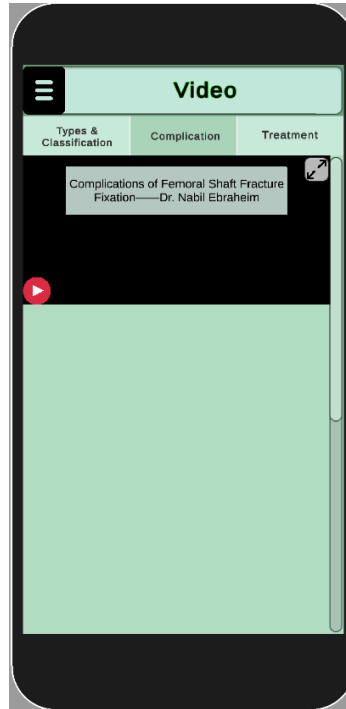
Figure 5.3.6: General Information

Figure 5.3.6 shows the general information page, where users can read through this page to gain additional basic knowledge, such as the risk factors and different classifications for identifying and grouping the bone fractures. There are links at the bottom or end of the general information for users' references.

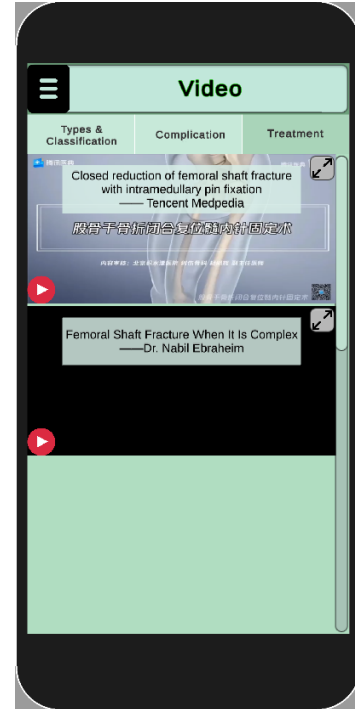
5.3.7 Video



*Figure 5.3.7-1: Video Lists
- Types & Classification*



*Figure 5.3.7-2: Video Lists
- Complication*



*Figure 5.3.7-3: Video Lists
- Treatment*

There are 3 categories for the video lists, which are types and classification, complication as well as treatment. This video module developed is mainly for users to deepen their learning of the different types of fracture knowledge.

5.3.8 Quiz

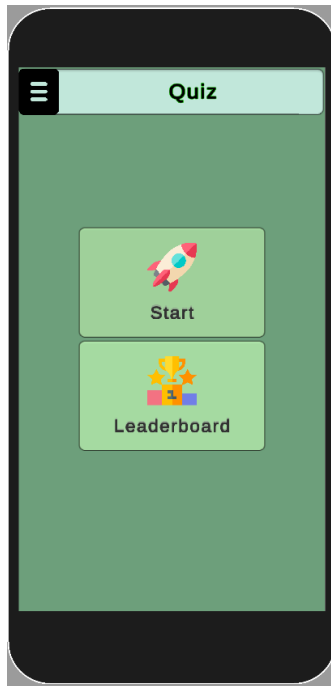


Figure 5.3.8-1: Quiz - Start

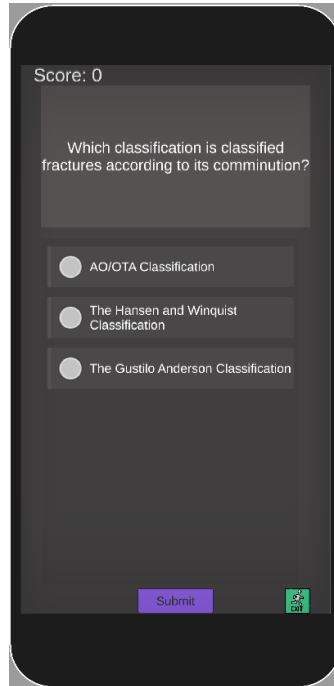


Figure 5.3.8-2: Quiz - Questions

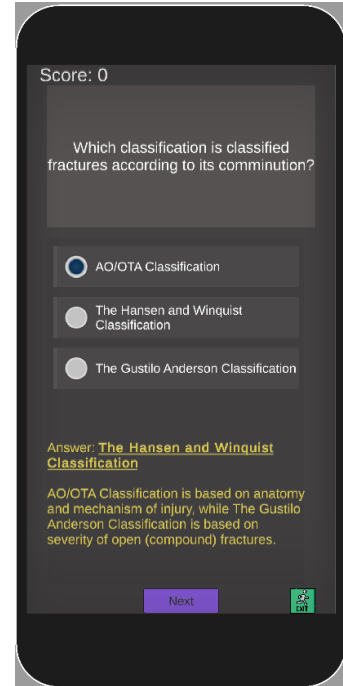


Figure 5.3.8-3: Quiz - Explanation

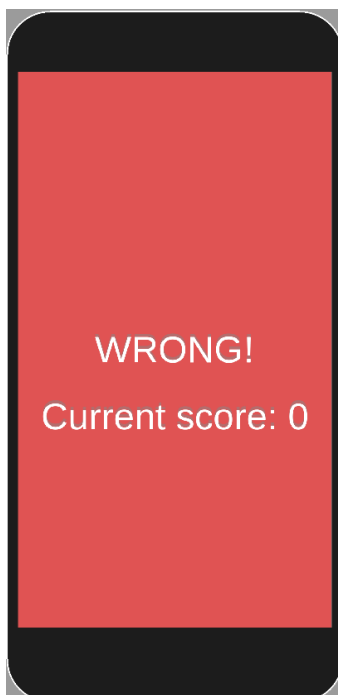


Figure 5.3.8-4: Quiz - Answer Wrong

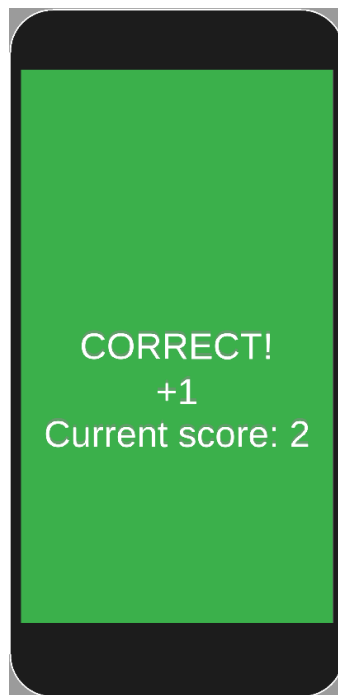


Figure 5.3.8-5: Quiz - Answer Correct

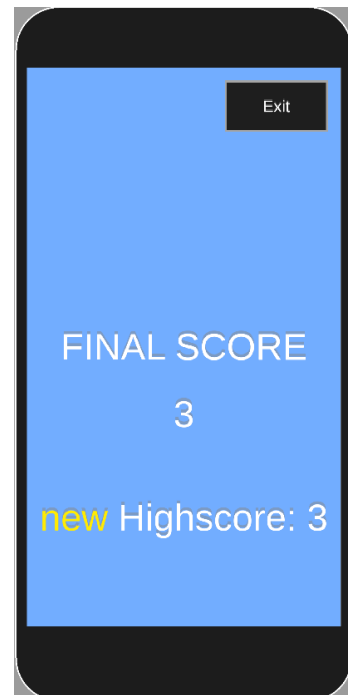


Figure 5.3.8-6: Quiz - Final Result

Rank	Username	Score
1	w	7
2	d	6
3	xm	0
4	q	0
5	test	0

Figure5.3.8-7: Quiz - Leaderboard

As in Figure 5.3.8-2, the question will be shown to users if they clicked the start button in Figure 5.3.8-1. The questions are displayed randomly, which means that the order of questions will not always be the same when users start the quiz. If users have submitted the wrong answer, there will be an explanation shown to users as shown in Figure 5.3.8-3. Then, it will show the status and current score of users with red background colour (Figure 5.3.8-4). Otherwise, it will show with a green background colour to represent the correct status, and score will be added (Figure 5.3.8-5), at the same time, update the current score at the top left corner of the question UI (refer Figure 5.3.8-2). Furthermore, if users have answered all the questions, the final result will be shown to users as in Figure 5.3.8-6. Users can also get know of their ranking number by clicking the “Leaderboard” button as shown in Figure 5.3.8-1, and the output would be as in Figure 5.3.8-7 shown. However, this feature is only available when the internet is available.

5.4 Implementation Issues and Challenges

There have been numerous challenges encountered throughout the development process, mainly due to the use of new technologies such as Unity, Blender, and Firebase. As this project involves the development of a mobile application with 3D models, the user interface has been the most challenging aspect to tackle. For instance, adjusting the component to the desired aspect ratio can be difficult as the screen aspect ratio may differ across various mobile devices. Additionally, the order of components in Unity is crucial and requires careful consideration. A specific example that has caused me considerable struggle is implementing the video fullscreen feature. Due to the application of the grid layout group for the video list, the scripting API of fullscreen mode cannot directly be used. As a result, I had to invest a significant amount of time to understand the overall component structure in Unity to successfully implement this feature.

Other than the user interface and Unity, I have also encountered issues with texturing the 3D model. Specifically, the texture of the “spongy bone” located on the inner part of the human femur bone appears strange after being applied to Unity. This issue may have arisen due to the undesirable baking of the texture from Blender, leading to visual differences between Blender and Unity.

Chapter 6

System Evaluation and Discussion

6.1 System Testing and Performance Metrics

To ensure the system functions correctly before release, system testing is imperative to discover flaws or defects in the written code. The technique chosen for this project is typically a combination of white-box testing and black-box testing. Black-box testing requires no prior programming knowledge of the internals of the system, but only observing the correctness of the outputs generated by providing inputs. There will be different test cases (unit testing) designed for the modules developed, the purpose is to test for the functional requirements.

On the other hand, to test the non-functional requirements, techniques such as time have been applied to test the responsiveness of the system. The Achievability test is also applied to test the ability of some features that developed in the system by repetitively doing the same action and then observing if the features are functioning well. A survey also served as another technique to test the overall non-functional requirements of this system. By collecting feedback through the survey, it is easy to assess how satisfied users are with the software, identify usability issues, and collect suggestions for improvements. All this information can then be used to improve the software and provide a better user experience.

6.2 Testing Setup and Result

6.2.1 Testing Setup

6.2.1.1 Physical Device Setup

It may be necessary to use a real device to test the touch and stylus input (such as scaling the bone model). Hence, Unity Remote 5 can be used in this case for testing. Following are the steps to setup a physical device:

1. In Unity project, go to Edit > Project Settings

2. Select “Editor”, change the Device to “Any Android Device”.
3. In the phone, download “Unity Remote 5” app from Google Play Store.
4. In the phone, to enable developer mode.
 - a. Go to Settings > More Setting > About Phone > tap Build Number for 7 times.
[not necessary to go through this process again if the phone is previously turn on the developer mode]
5. Link the phone with the laptop using USB cable.
6. In the phone, to enable USB debugging.
 - a. Go to Settings > System > Developer options > enable USB debugging
 - b. Click OK
 - c. Allow USB debugging
7. Open or start the “Unity remote 5” app on phone and run the Unity project from laptop.

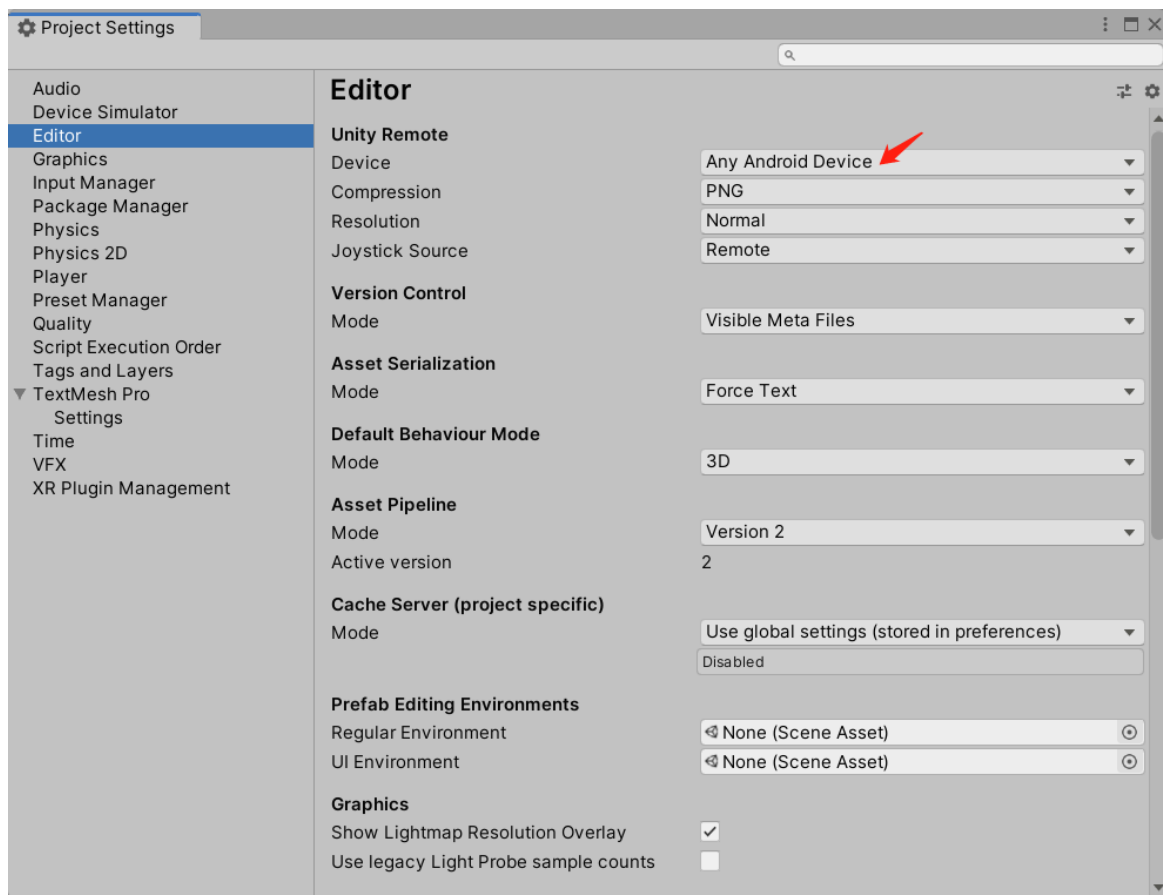


Figure 6.2.1.1: Physical Device Setup

6.2.2 Result

6.2.2.1 Profile Module

There are different features provided in the profile module, and it will be divided into different tests.

Test 1: Sign Up

Requirements for creating a new account:

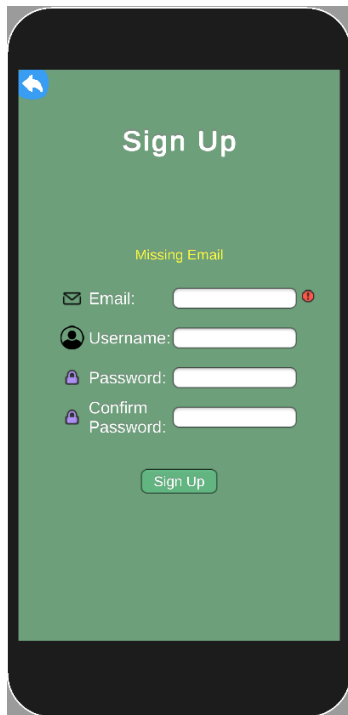
- All the fields are required to be filled. (Email, username, password, confirmation password)
- The input field for email should be in the correct format.
- The password is limited to at least 8 characters, with both digits and characters.
- Both password and confirmation password have to be matched to fulfil the registration requirement.

Table 6.2.2.1-T1: Unit Testing - Sign Up

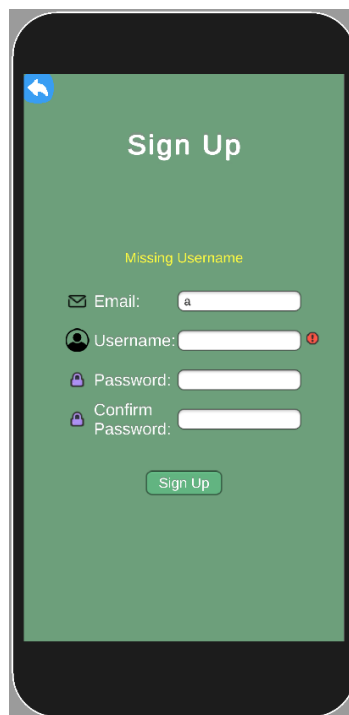
Test Case	Description	Actions	Test Data	Expected Result	Status
1	Check required field by not filling any data.	<ol style="list-style-type: none">1. Do not fill in any data.2. Click the “Sign Up” button.3. Repeat the steps above for all the input fields.	N/A	It should show an exclamation mark (“!”) logo beside the field, and display error message at the top of all the fields.	Pass

2	Check email input field with wrong format data.	<ol style="list-style-type: none"> 1. Fill in a not email format text in email input field. 2. Click the “Sign Up” button. 	<ol style="list-style-type: none"> 1. abcdef@ 2. abcef@gmail 3. abcdegmail.com 	It should show an exclamation mark (“!”) logo beside the field, and display error message at the top of all the fields.	Pass
3	Check sign up status if input with different passwords.	<ol style="list-style-type: none"> 1. Fill in both the password and confirmation password with different input. 	Password field: test112233 Confirmation password field: 112233test	It should show exclamation mark (“!”) beside both the password input fields, and display error message at the top of all the input fields.	Pass
4	Check sign up status if input with weak password.	<ol style="list-style-type: none"> 1. Fill in invalid password that does not fulfil requirements. (e.g., less than 8 characters, without the 	<ol style="list-style-type: none"> 1. Test12 2. Testingggg 3. 12345678 	It should show exclamation mark (“!”) beside the password input field, and display error	Pass

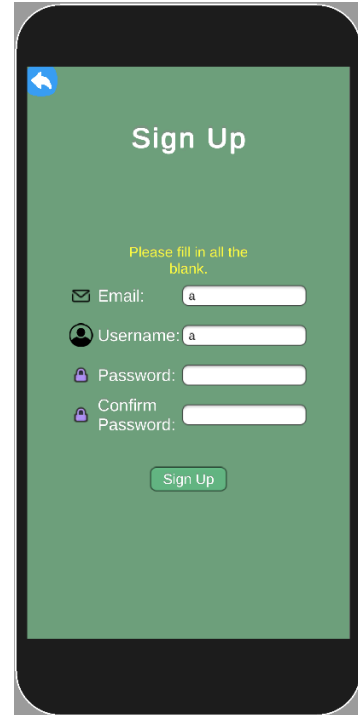
		characters and digit mixed)		message at the top of all the input fields.	
5	Check with inputting all the valid data	<ol style="list-style-type: none"> 1. Input correct format of email. 2. Input any username. 3. Input the match passwords. 4. Click “Sign Up” button. 	Email: xinmi503@lutar.my Username: Lam Password: UPassThis!28 Confirmation password: UPassThis!28	It should pop out a message box showing the success message and redirect users back to the sign in page.	Pass
6	Check if creating 2 accounts with the same email address.	<ol style="list-style-type: none"> 1. Sign up again with the same email address with above test case. 	Email: xinmi503@lutar.my Username: XinMi Password: UPassThis!88 Confirmation password: UPassThis!88	It should show exclamation mark (“!”) beside the email input field, and display error message at the top of all the input fields.	Pass



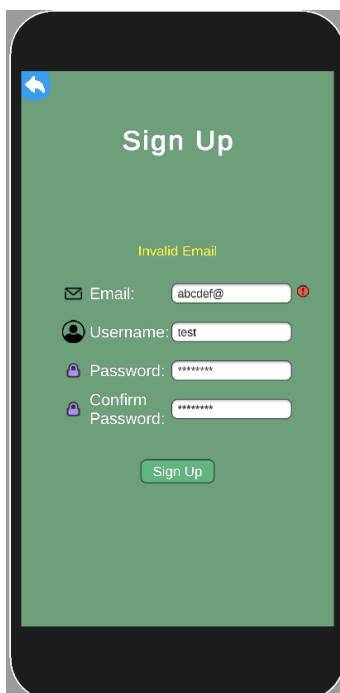
*Figure 6.2.2.1-T1(1):
Empty Email (Test
Case 1)*



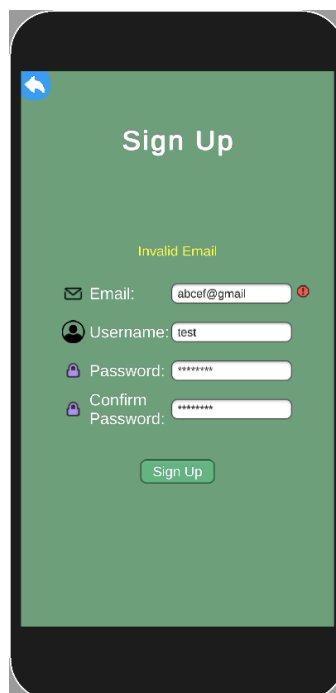
*Figure 6.2.2.1-T1(2):
Empty Username (Test
Case 1)*



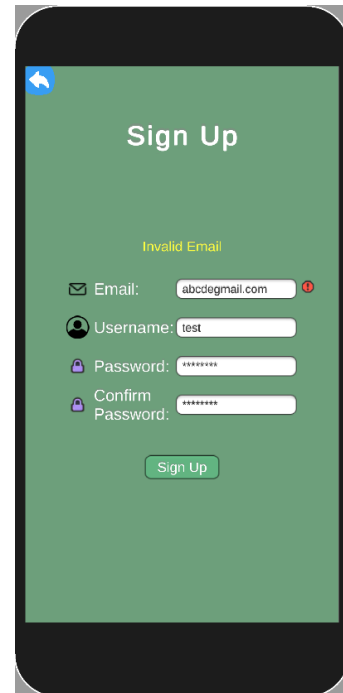
*Figure 6.2.2.1-T1(3):
Empty Password (Test
Case 1)*



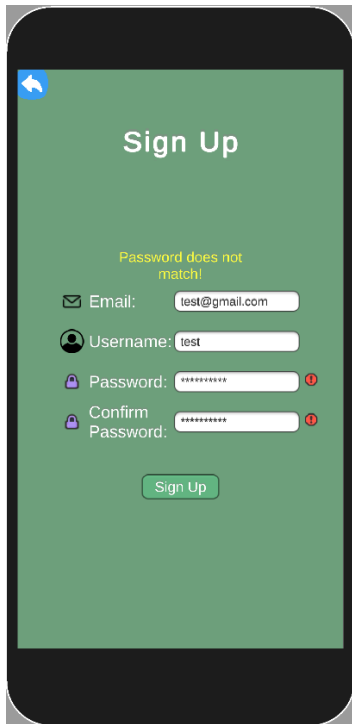
*Figure 6.2.2.1-T1(4):
Invalid Email 1 (Test
Case 2)*



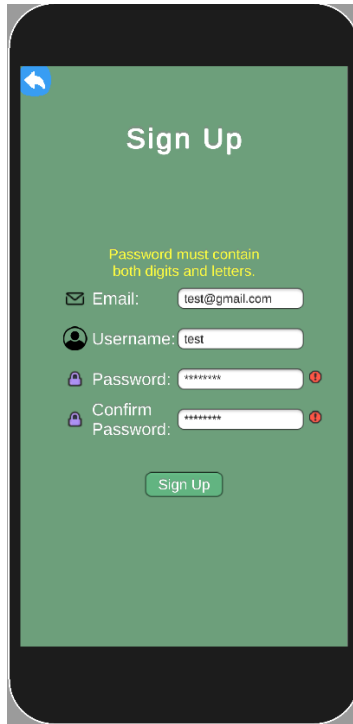
*Figure 6.2.2.1-T1(5):
Invalid Email 2 (Test
Case 2)*



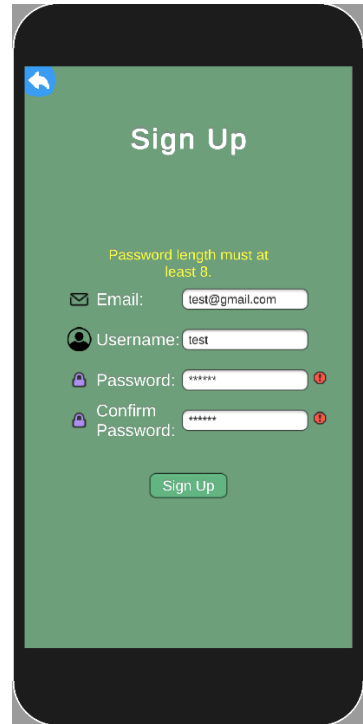
*Figure 6.2.2.1-T1(6):
Invalid Email 3 (Test
Case 2)*



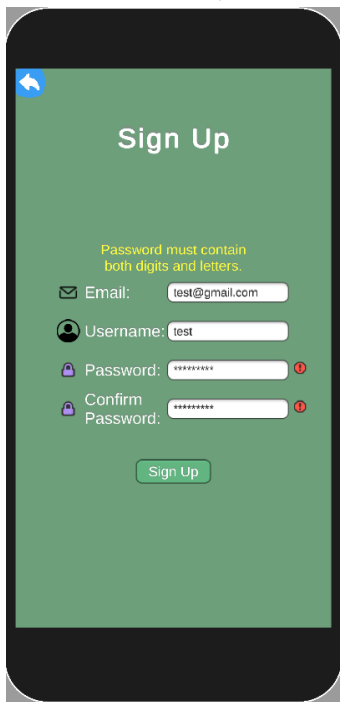
*Figure 6.2.2.1-T1(7):
Different Password (Test
Case 3)*



*Figure 6.2.2.1-T1(8):
Invalid Password 1 (Test
Case 4)*



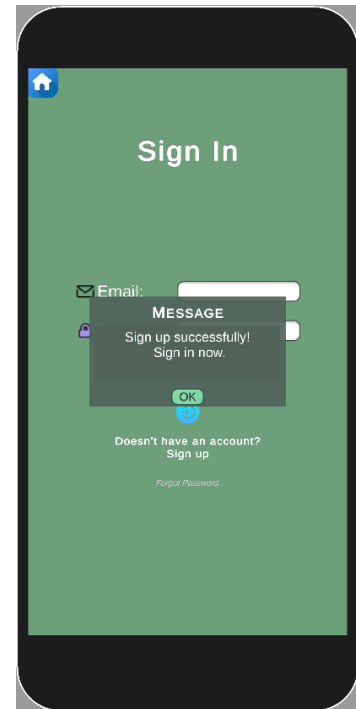
*Figure 6.2.2.1-T1(9):
Invalid Password 2 (Test
Case 4)*



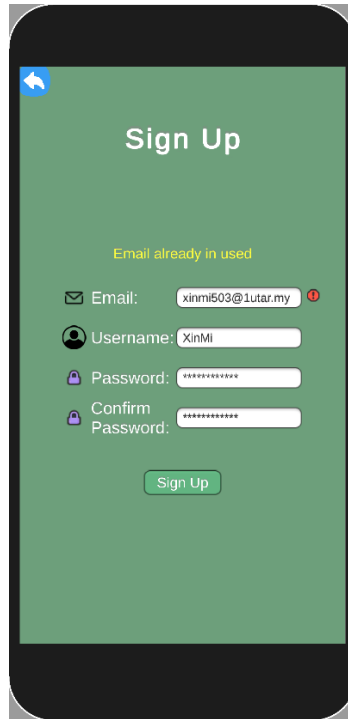
*Figure 6.2.2.1-T1(10):
Invalid Password 3
(Test Case 4)*



*Figure 6.2.2.1-T1(11):
Valid Inputs
(Test Case 5)*



*Figure 6.2.2.1-T1(12):
Sign Up Successful
(Test Case 5)*



*Figure 6.2.2.1-T1(13):
Sign Up with Same Email
(Test Case 6)*

Test 2: Sign In

Requirements for signing in an account:

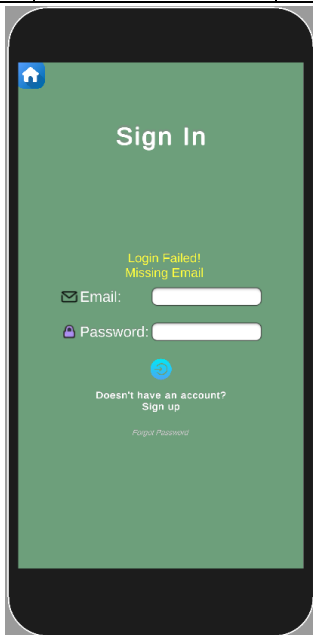
- All the input fields must be filled.
- Accounts should be created before signing in.

Table 6.2.2.1-T2: Unit Testing - Sign In

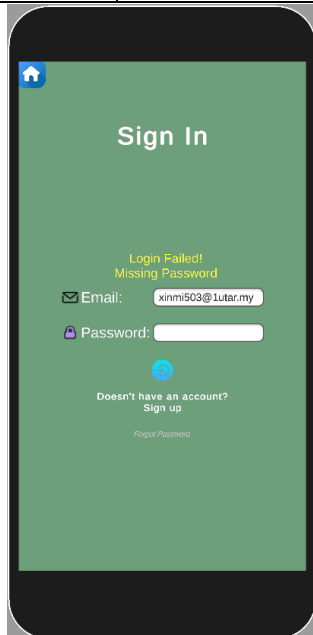
Test Case	Description	Actions	Test Data	Expected Result	Status
1	Check required field by not filling any data.	<ol style="list-style-type: none"> 1. Do not fill in any data. 2. Click the "Sign in" button. 	N/A	It should show error message at the top of all the input fields.	Pass

		3. Repeat the steps above for all the input fields.			
2	Check sign in status if using an email address that has not been signed up.	<ol style="list-style-type: none"> 1. Input an email without signing up before. 2. Click “Sign In” button. 	aaa@gmail.com	It should show error message at the top of all the input fields.	Pass
3	Check sign in status if enter a wrong password	<ol style="list-style-type: none"> 1. Input the signed up email address. 2. Input the wrong password. 3. Click “Sign In” button. 	Email: xinmi503@lutar.my Password: testing123	It should show error message at the top of all the input fields.	Pass
4	Check sign in status if inputting all the correct information.	<ol style="list-style-type: none"> 1. Input the correct email address. 2. Input the correct password. 	Email: xinmi503@lutar.my Password: UPassThis!28	It should pop up a message box showing the success message and redirect	Pass

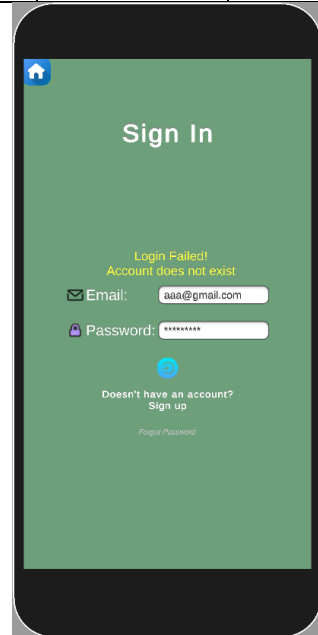
		3. Click “Sign In” button.		users to the main page.	
--	--	----------------------------------	--	----------------------------	--



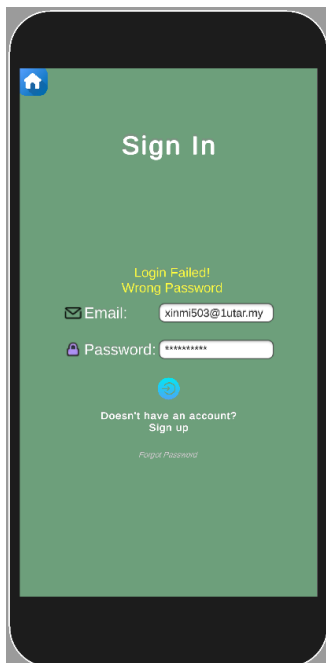
*Figure 6.2.2.1-T2(1):
Empty Email (Test
Case 1)*



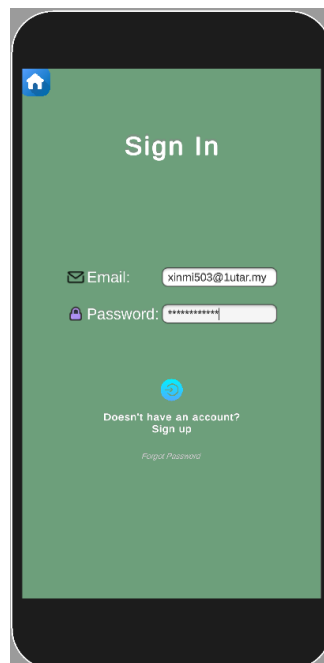
*Figure 6.2.2.1-T2(2):
Empty Password (Test
Case 1)*



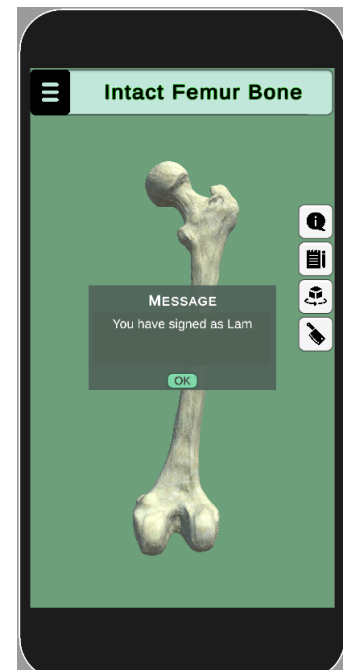
*Figure 6.2.2.1-T2(3):
Account Not Exists
(Test Case 2)*



*Figure 6.2.2.1-T2(4):
Wrong Password
(Test Case 3)*



*Figure 6.2.2.1-T2(5):
Input with Correct
Information (Test Case 4)*



*Figure 6.2.2.1-T2(6):
Sign In Successful
(Test Case 4)*

Test 3: Reset Password

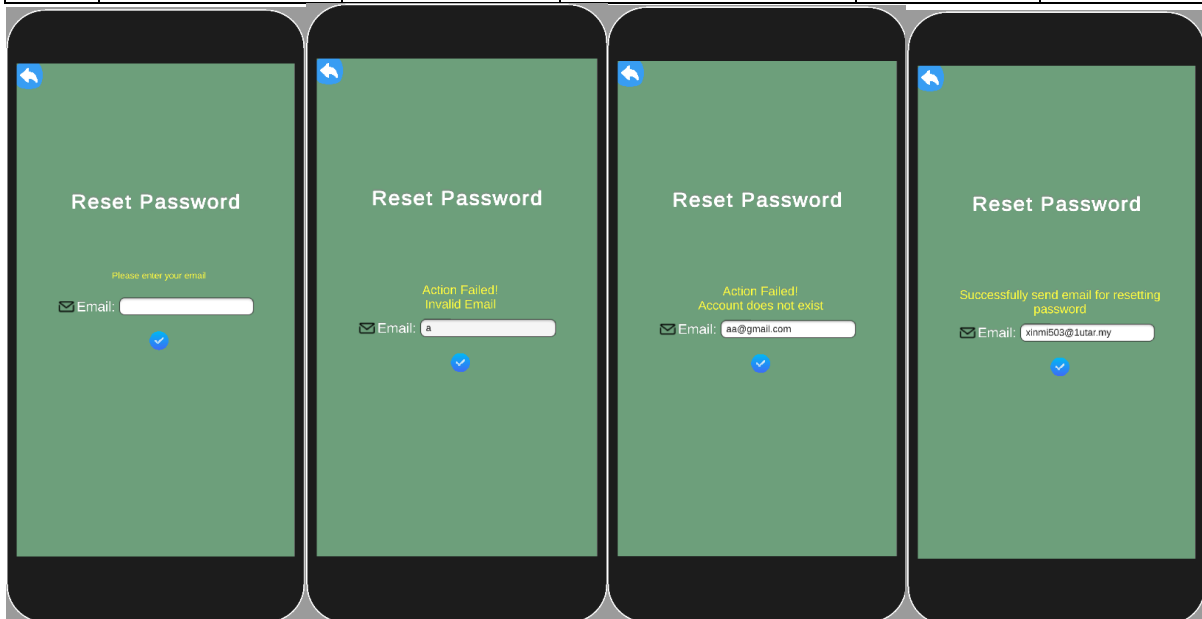
Requirements for resetting password:

- Email address input field must be filled.
- The email address should be valid.
- The email address should be created as an account before.

Table 6.2.2.1-T3: Unit Testing - Reset Password

Test Case	Description	Actions	Test Data	Expected Result	Status
1	Check required field by not filling any data.	1. Do not fill in any data for the email input field. 2. Click the “tick” button.	N/A	It should show error message at the top of the input fields.	Pass
2	Check submit status if inputting invalid email address.	1. Input invalid email address. 2. Click “tick” button.	a	It should show error message at the top of the input fields.	Pass
3	Check submit status if inputting email that has not been signed up.	1. Input valid email that has not been signed up before.	aa@gmail.com	It should show error message at the top of the input fields.	Pass

		2. Click “tick” button.			
4	Check submit status if input the correct information.	1. Input valid and correct email address. 2. Click “tick” button.	xinmi503@lutar.my	It should show success message at the top of the input field and user will receive an email to reset the password.	Pass



*Figure 6.2.2.1-T3(1):
Empty Email (Test
Case 1)*

*Figure 6.2.2.1-T3(2):
Invalid Email (Test
Case 2)*

*Figure 6.2.2.1-T3(3):
Account Not Exists
(Test Case 3)*

*Figure 6.2.2.1-T3(4):
Submit Successful
(Test Case 4)*

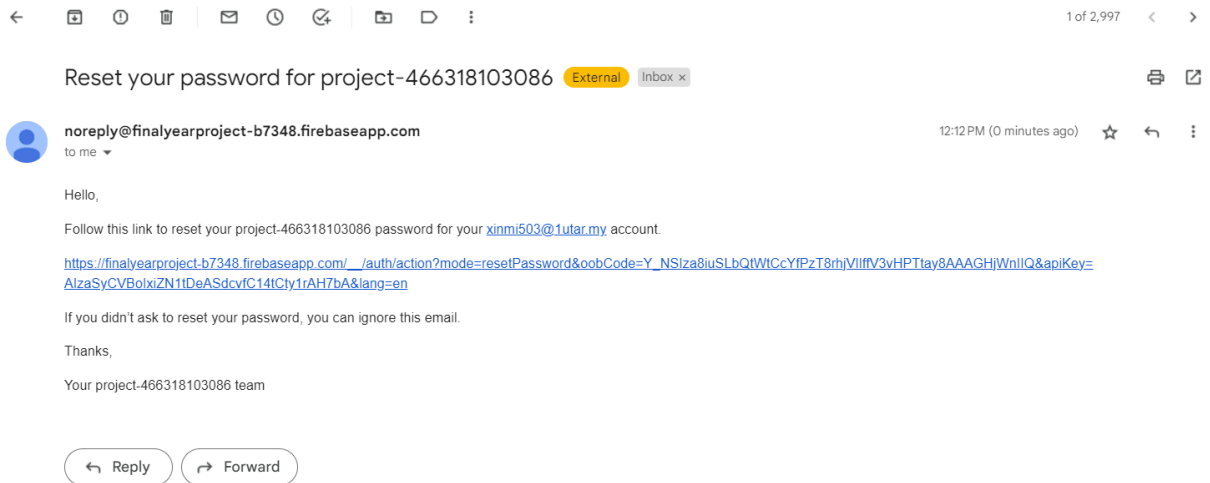
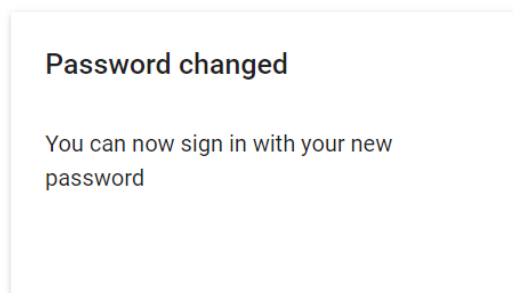


Figure 6.2.2.1-T3(5): Reset Password Email Received (Test Case 4)

A screenshot of a web form titled 'Reset your password' for the user 'xinmi503@1utar.my'. It features a text input field labeled 'New password' with a toggle icon for visibility. A blue 'SAVE' button is located at the bottom right of the form.

*Figure 6.2.2.1-T3(6):
Reset Password (Test
Case 4)*



*Figure 6.2.2.1-T3(7):
Reset Password Successful
(Test Case 4)*

Test 4: Update Username

Requirements for updating username:

- Input field should not be blank.
- Username should not be same with the current.

Table 6.2.2.1-T4: Unit Testing - Update Username

Test Case	Description	Actions	Test Data	Expected Result	Status
1	Check required field by not filling any data.	1. Do not fill in any data for the input field. 2. Click the “tick” button.	N/A	It should show error message at the top of the input fields.	Pass
2	Check update status if input the same username to the current.	1. Input the same username. 2. Click “tick” button.	Lam	It should show error message at the top of the input fields.	Pass
3	Check update status if input a new username.	1. Input a new username. 2. Click “tick” button.	Lamm	It should show success message at the top of the input fields.	Pass

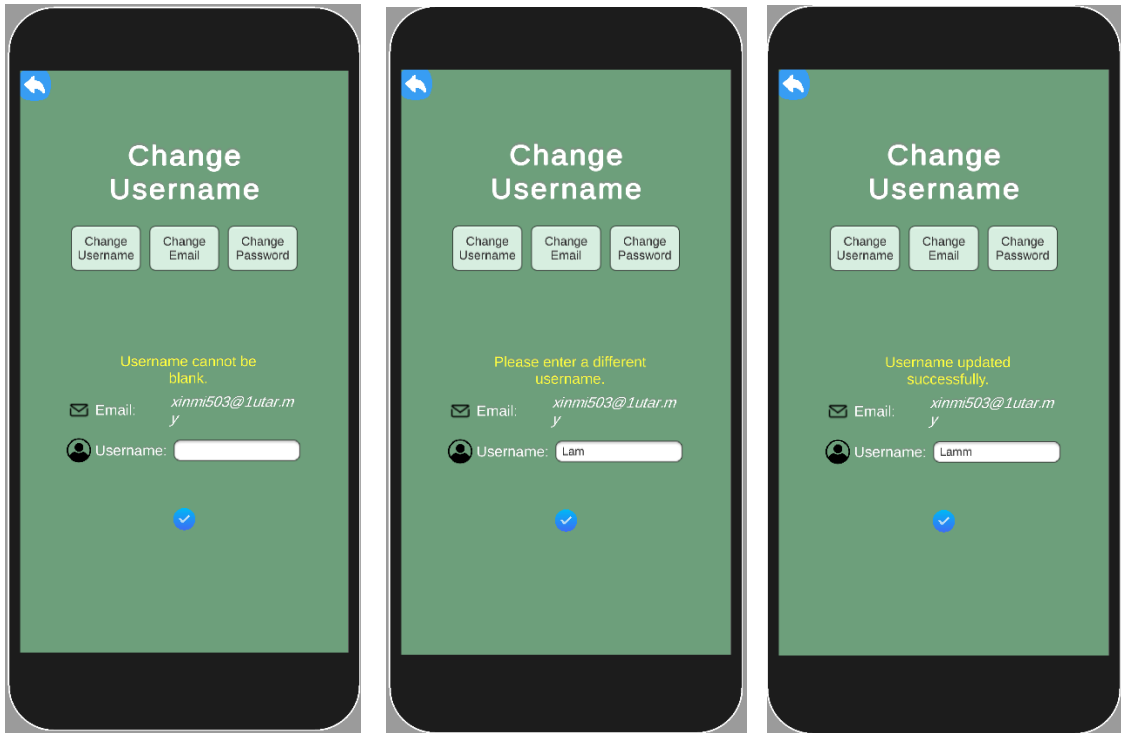


Figure 6.2.2.1-T4(1):
Empty Username (Test Case 1)

Figure 6.2.2.1-T4(2):
Same Username (Test Case 2)

Figure 6.2.2.1-T4(3):
New Username (Test Case 3)

Test 5: Update Password

Requirements for updating password:

- All the input fields should not be blank.
- The current password must be correct. [current password for this account: UPassThis!88]
- Both the new password and confirmation password must be matched.
- Password length must be equal or greater than 8.
- Password must mix with both characters and digits.

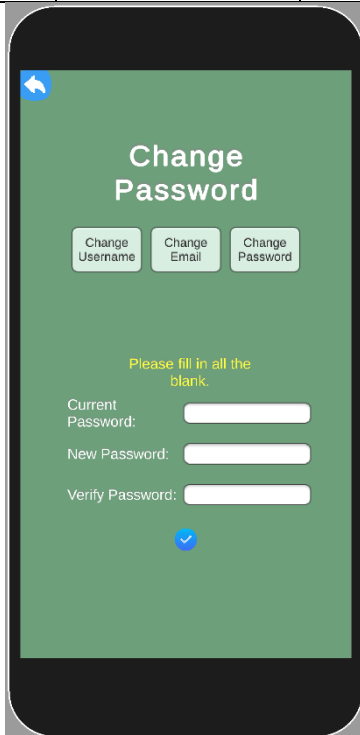
Table 6.2.2.1-T5: Unit Testing - Update Password

Test Case	Description	Actions	Test Data	Expected Result	Status
1	Check required field by not filling any data.	1. Do not fill in any data	N/A	It should show error message at	Pass

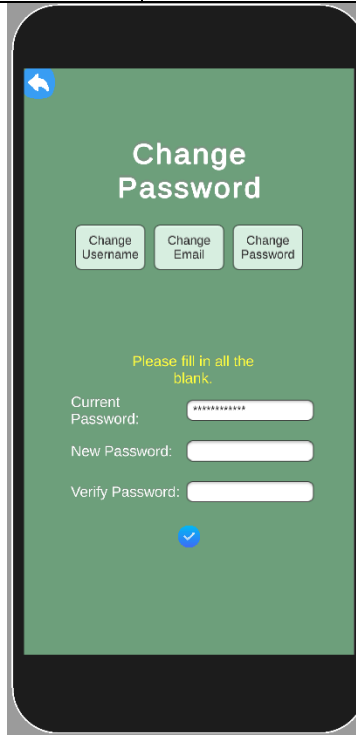
		<p>for the input field.</p> <ol style="list-style-type: none"> Click the “tick” button. Repeat steps above for all the other input fields. 		<p>the top of the input fields.</p>	
2	<p>Check update status if inputting different password.</p>	<ol style="list-style-type: none"> Input the correct current password. Input different password for new password and verify password. Click “tick” button. 	<p>Current password: UPassThis!88</p> <p>Password: UPassThis!28</p> <p>Verify password: testinggg12</p>	<p>It should show error message at the top of the input fields.</p>	Pass
3	<p>Check update status if inputting invalid password.</p>	<ol style="list-style-type: none"> Input the correct current password. Input the invalid password 	<p>Current password: UPassThis!88</p> <p>Password: asdfghjkl</p> <p>Verify password: asdfghjkl</p>	<p>It should show error message at the top of the input fields.</p>	Pass

		<p>to make an update.</p> <p>3. Click “tick” button.</p>			
4	<p>Check update status if inputting a valid but incorrect password.</p>	<p>1. Input the incorrect current password for the account.</p> <p>2. Input a matched password to make an update.</p> <p>3. Click the “tick” button.</p>	<p>Current password: UPassThis!28</p> <p>Password: changeme123</p> <p>Verify password: changeme123</p>	<p>It should show error message at the top of the input fields.</p>	Pass
5	<p>Check update status if inputting all the valid and correct information.</p>	<p>1. Input the correct current password.</p> <p>2. Input the same password for the new password and verify password.</p>	<p>Current password: UPassThis!88</p> <p>Password: UPassThis!28</p> <p>Verify password: UPassThis!28</p>	<p>It should show a success message at the top of input fields.</p>	Pass

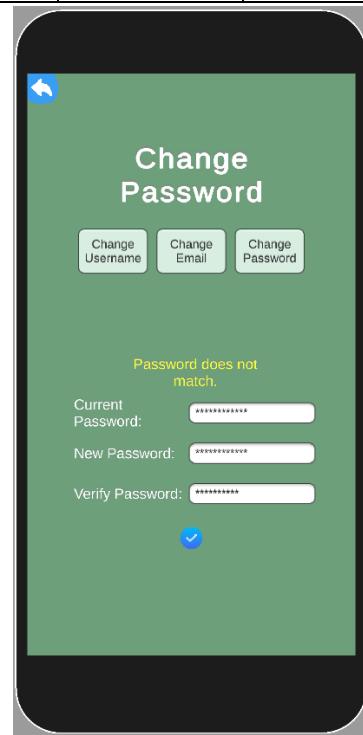
		3. Click “tick” button.			
--	--	-------------------------	--	--	--



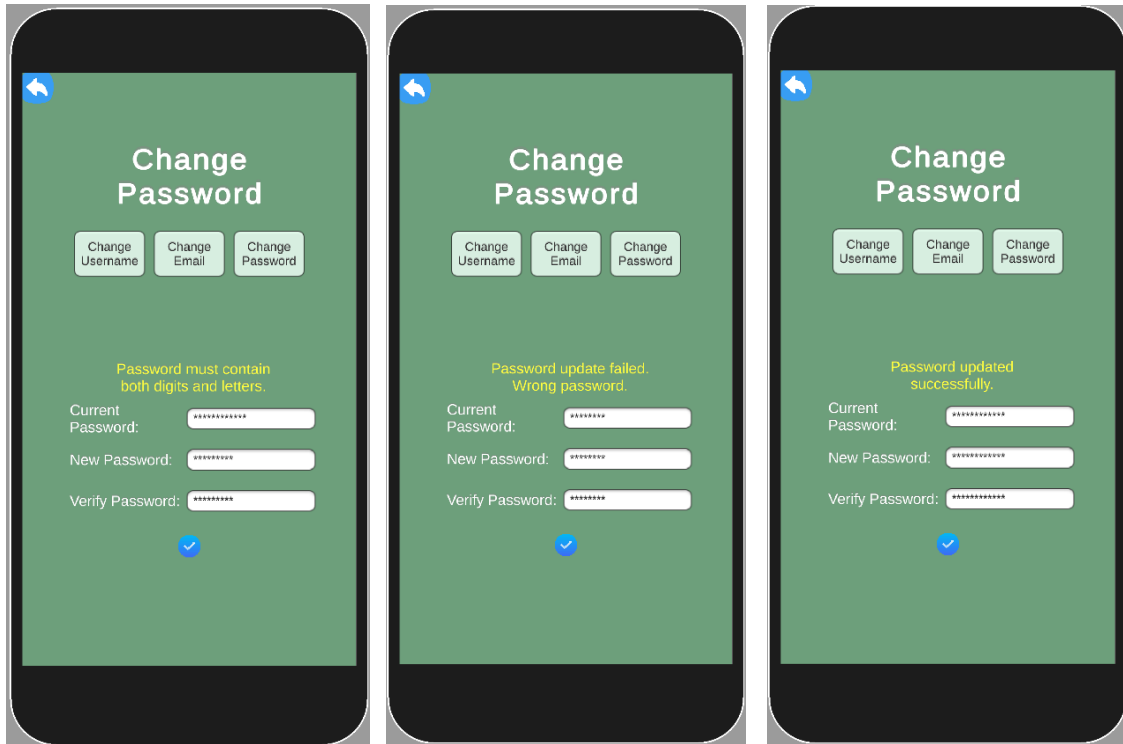
*Figure 6.2.2.1-T5(1):
Empty All (Test Case 1)*



*Figure 6.2.2.1-T5(2):
Empty Password
Fields (Test Case 1)*



*Figure 6.2.2.1-T5(3):
Password Mismatch
(Test Case 2)*



*Figure 6.2.2.1-T5(4):
Invalid Password
(Test Case 3)*

*Figure 6.2.2.1-T5(5):
Incorrect Current
Password (Test Case 4)*

*Figure 6.2.2.1-T5(6):
Password Update
Successful (Test Case 5)*

Test 6: Update Email

Requirements for updating email:

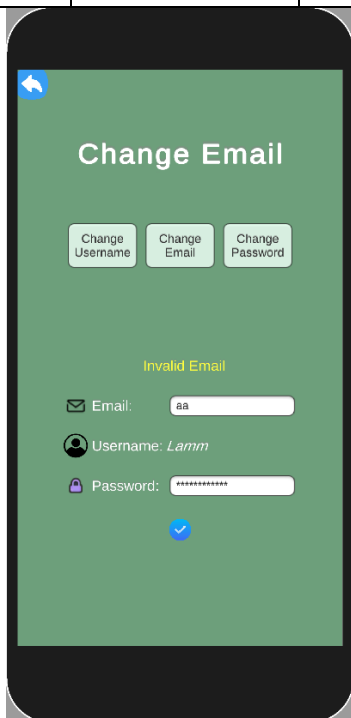
- All the input fields should not be blank.
- Email should be different from the current. [current email: xinmi503@1utar.my]
- Email must be valid and not registered before.

Table 6.2.2.1-T6: Unit Testing - Update Email

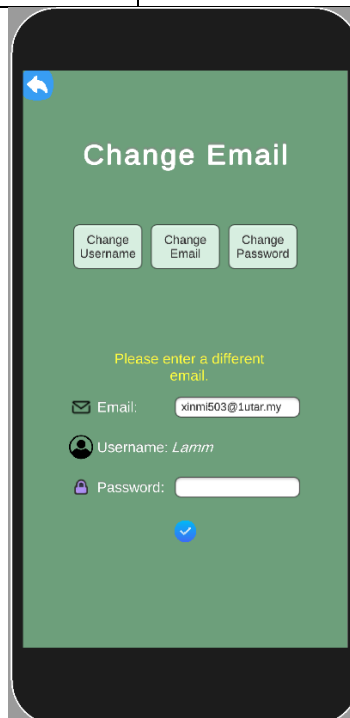
Test Case	Description	Actions	Test Data	Expected Result	Status
1	Check update status if inputting with	1. Input an invalid email address.	Email: aa Password: UPassThis!28	It should show error message at the top of	Pass

	an invalid email address.	<ol style="list-style-type: none"> Input the correct password. Click “tick” button. 		the input fields.	
2	Check update status if inputting the same email address.	<ol style="list-style-type: none"> Input with the same email address as current. Click “tick” button. 	xinmi503@lutar.my	It should show error message at the top of the input fields.	Pass
3	Check update if inputting email address that has been registered before.	<ol style="list-style-type: none"> Input email address that has been registered before. Input the correct password. Click “tick” button. 	Email: xinmi44@gmail.com Password: UPassThis!28	It should show error message at the top of the input fields.	Pass
4	Check update status if leaving blank on the password field	<ol style="list-style-type: none"> Input a new email without registering before. 	Email: xinmi1986@gmail.com Password:	It should show error message at the top of	Pass

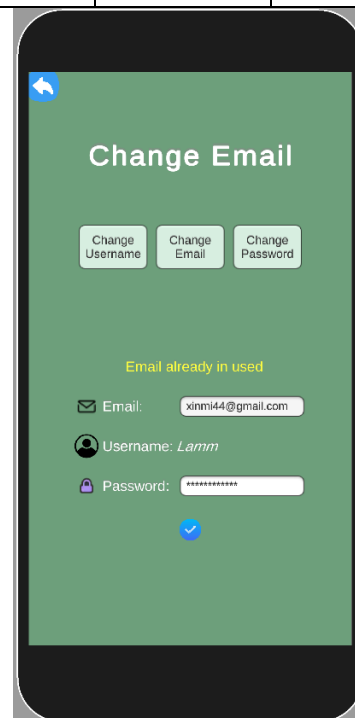
		2. Click “tick” button.		the input fields.	
5	Check update status if inputting with all the correct and valid information.	<ol style="list-style-type: none"> 1. Input a valid email that has not been registered before. 2. Input correct password. 3. Click “tick” button. 	Email: xinmi1986@gmail.com Password: UPassThis!28	It should show a success message at the top of the input fields.	



*Figure 6.2.2.1-T6(1):
Invalid Email (Test
Case 1)*



*Figure 6.2.2.1-T6(2):
Same Email (Test
Case 2)*



*Figure 6.2.2.1-T6(3):
Occupied Email (Test
Case 3)*

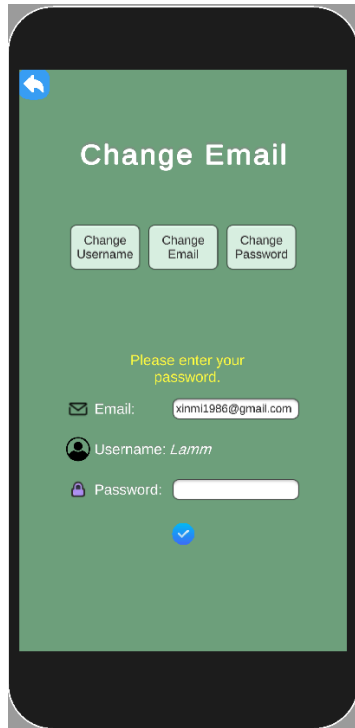


Figure 6.2.2.1-T6(4):
Empty Password (Test Case 4)

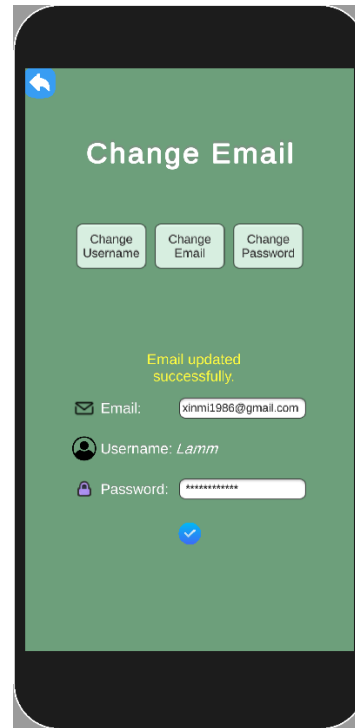


Figure 6.2.2.1-T6(5):
Email Update Successful (Test Case 5)

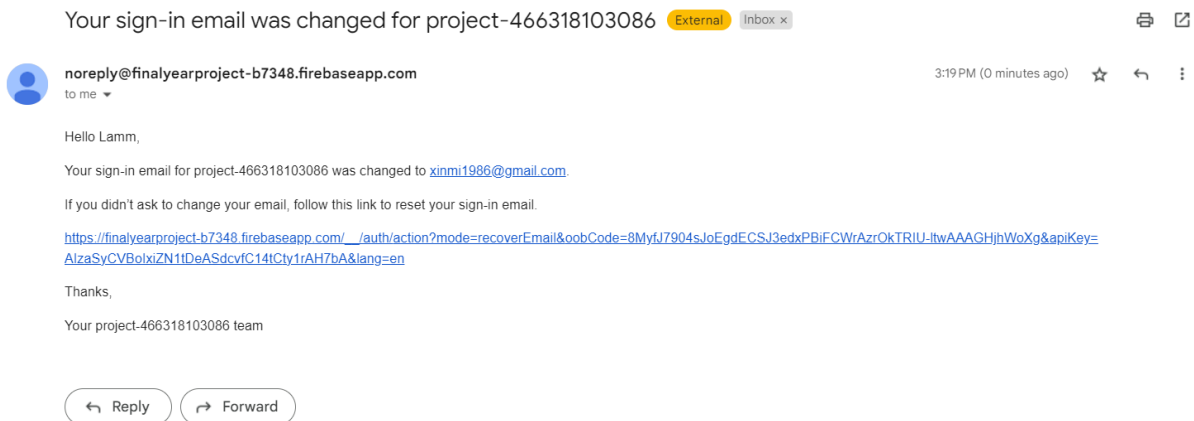


Figure 6.2.2.1-T6(6): Notification Email Received (Test Case 5)

6.2.2.2 Bone Module

There are different features included in bone module, where it allows users to interact with the 3D bone models (rotate, scale, touch), add text as notes, read basic information. The parameter used for testing this module involves time, which represents the responsiveness of the application when user trying to interact with the bone models and retrieve or upload notes data from and to the cloud.

Test 1: Upload Notes to Firebase Cloud

```
public void SaveNote()
{
    PlayerPrefs.SetString(title, notes.GetComponent<TMP_InputField>().text);
    Debug.Log("Start time (upload to firebase): " + Time.time * 1000);
    StartCoroutine(Utility.uploadFirebase());
    Debug.Log("Finish time (upload to firebase): " + Time.time * 1000);
}
```

Figure 6.2.2.2-T1(1): Code - Upload Notes to Firebase

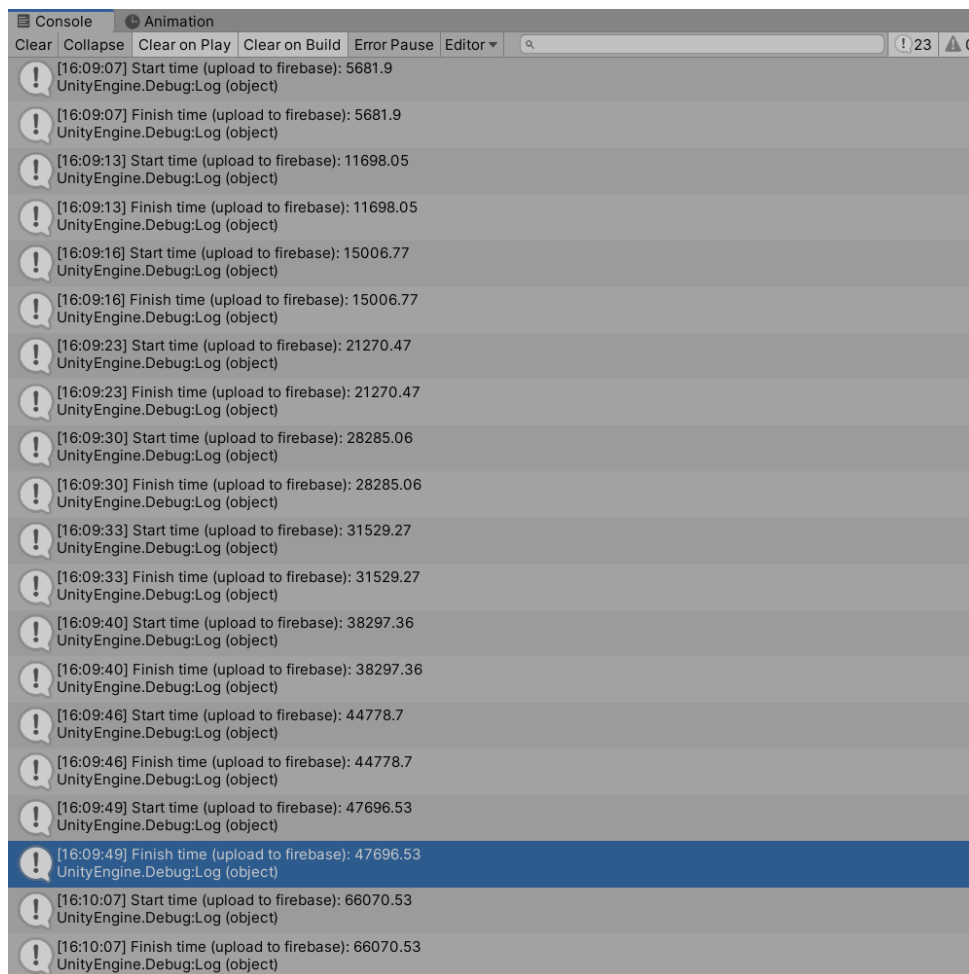


Figure 6.2.2.2-T1(2): Results - Uploading Notes to Firebase Cloud

Table 6.2.2.2-T1: Time Testing - Notes Uploading to Firebase Cloud

Test time	Start time (in ms)	Finish time (in ms)	Time taken (in ms)
1	5681.9	5681.9	0
2	11695.05	11695.05	0
3	15006.77	15006.77	0
4	21270.47	21270.47	0
5	28285.06	28285.06	0
6	31529.27	31529.27	0
7	38297.36	38297.36	0
8	44778.7	44778.7	0
9	47696.53	47696.53	0
10	66070.53	66070.53	0
Average			0

There is a total of 10-time tests on this feature. Figure 6.2.2.2-T1(1) indicates the coding for uploading notes to firebase cloud. There are 2 lines of codes added to deal with this test, which is displaying the system time before and after calling the uploadFirebase() function. As Table 6.2.2.2-T2 shows, the speed of retrieving data is very fast, and there is no gap between the start time and finish time.

Test 2: Retrieve Realtime Data from Firebase Cloud

```
void HandleValueChanged(object sender, ValueChangedEventArgs args)
{
    if (args.DatabaseError != null)
    {
        Debug.LogError(args.DatabaseError.Message);
        return;
    }

    // Retrieve the updated data from the snapshot
    if (args.Snapshot != null && args.Snapshot.Exists)
    {
        Debug.Log("Start time (retrieve real time data): " + Time.time * 1000);
        StartCoroutine(CheckAndUploadLocalData());
        Debug.Log("Finish time (retrieve real time data): " + Time.time * 1000);
    }
}
```

Figure 6.2.2.2-T2(1): Code - Retrieve Realtime Data from Firebase Cloud

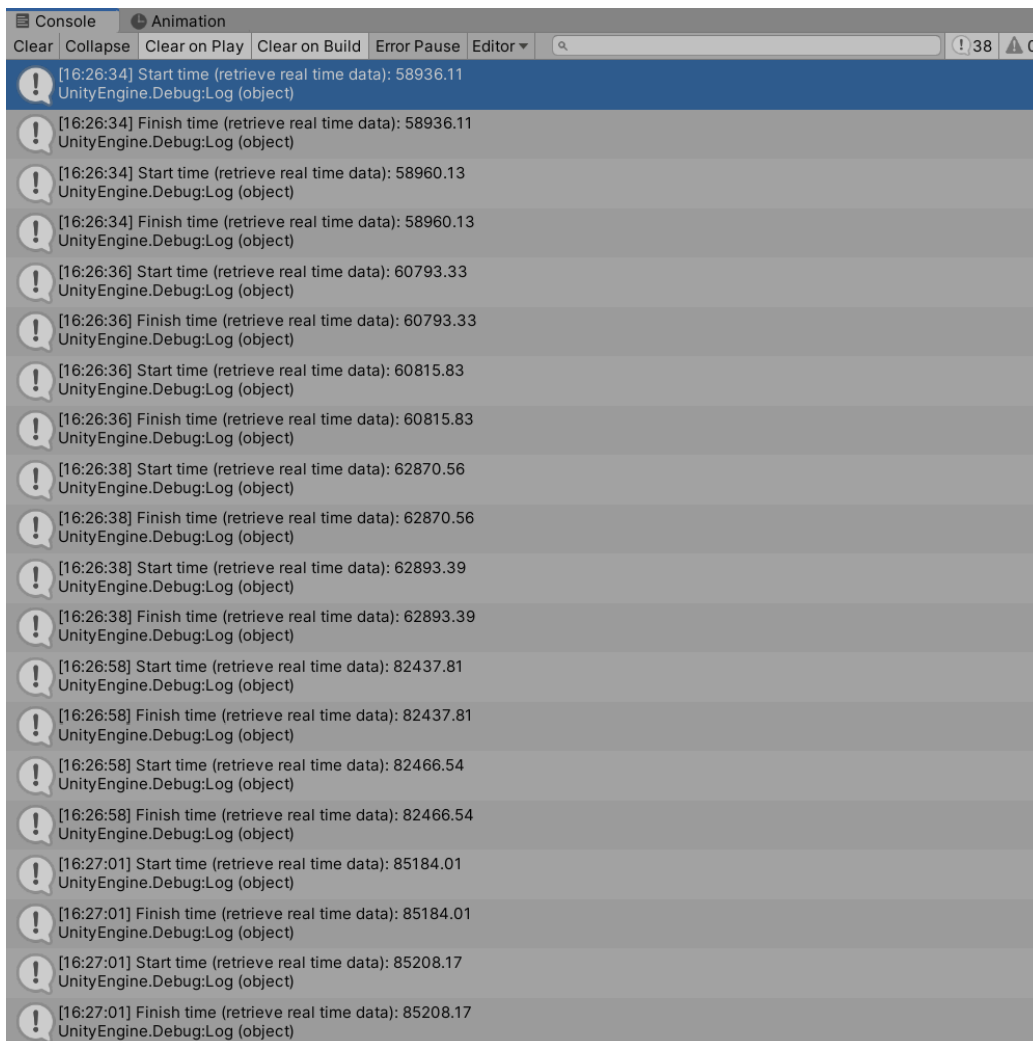


Figure 6.2.2.2-T2(2): Results - Retrieving Realtime Data

Table 6.2.2.2-T2: Time Testing - Retrieving Realtime Data

Test time	Start time (in ms)	Finish time (in ms)	Time taken (in ms)
1	58936.11	58936.11	0
2	58960.13	58960.13	0
3	60793.33	60793.33	0
4	60815.83	60815.83	0
5	62870.56	62870.56	0
6	62893.39	62893.39	0
7	82437.81	82437.81	0
8	82466.54	82466.54	0
9	85184.01	85184.01	0
10	85208.17	85208.17	0
Average			0

Figure 6.2.2.2-T2(1) represents the code of retrieving data from firebase cloud in real time. There are 2 lines of codes added to identify the actual time taken to retrieve the data. There is a total of 10 times of testing has run for this test. As Table 6.2.2.2-T2 shows, the speed of retrieving data is very fast, and there is no gap between the start time and finish time.

Test 3: Bone Interaction

Table 6.2.2.2-T3(1): Unit Testing - Bone Interaction

Test Case	Description	Actions	Test Data	Expected Result	Status
1	Check if the labeling is functioning well.	<ol style="list-style-type: none"> 1. Disable the rotate feature if it is currently active by clicking again on it. 2. Touch any part of the 3D bone model. 3. Repeat step 1 to touch other part of the model. 	Touch input with one finger or mouse click and drag	It should display a label along with a highlight colour on the part of the bone if user touches the part of the bone with labeling.	Pass
2	Check if the rotation feature is functioning well.	<ol style="list-style-type: none"> 1. Disable the cut feature if it is currently active by clicking again on it. 2. Click on the "Rotate" button. 3. Swipe left, right, up, and down on the bone model. 	Touch input with one finger or mouse click and drag	The 3D bone model should be able to turn around if user swiping around the screen	Pass

3	Check if the cutting feature is functioning well.	<ol style="list-style-type: none"> 1. Disable the rotate feature if it is currently active by clicking again on it. 2. Click on the “Knife” button. 3. Swipe around the bone model. 	Touch input with one finger or mouse click and drag	It should show a colouring cut effect on the screen, and display with an inner femur bone model along with the cutting sound effect.	Pass
4	Check if the scaling feature is functioning well.	<ol style="list-style-type: none"> 1. Zoom the 3D bone model in and out with 2 fingers. 	Touch input with 2 fingers	The 3D bone model should be smaller if user try to zoom out, and be larger if zoom in.	Pass

- **Achivaibility test on bone model rotation**

This test is mainly to test the rotation feature when swiping up, down, left, and right on the bone model. There is a total of 10-time tests on the correctness of the bone model rotation direction based on the swipe direction. Table 6.2.2.2-T3(2) and Figure 6.2.2.2-T3(1) have clearly illustrated the relationship between swipe direction and bone model rotation direction, while Table 6.2.2.2-T3(3) represents the results.

Table 6.2.2.2-T3(2): Relationship between Swipe Direction and Bone Model Rotation Direction

Swipe Direction	Bone Model Rotation Direction
Up, down	Rotate in y-axis
Left, right	Rotate in x-axis

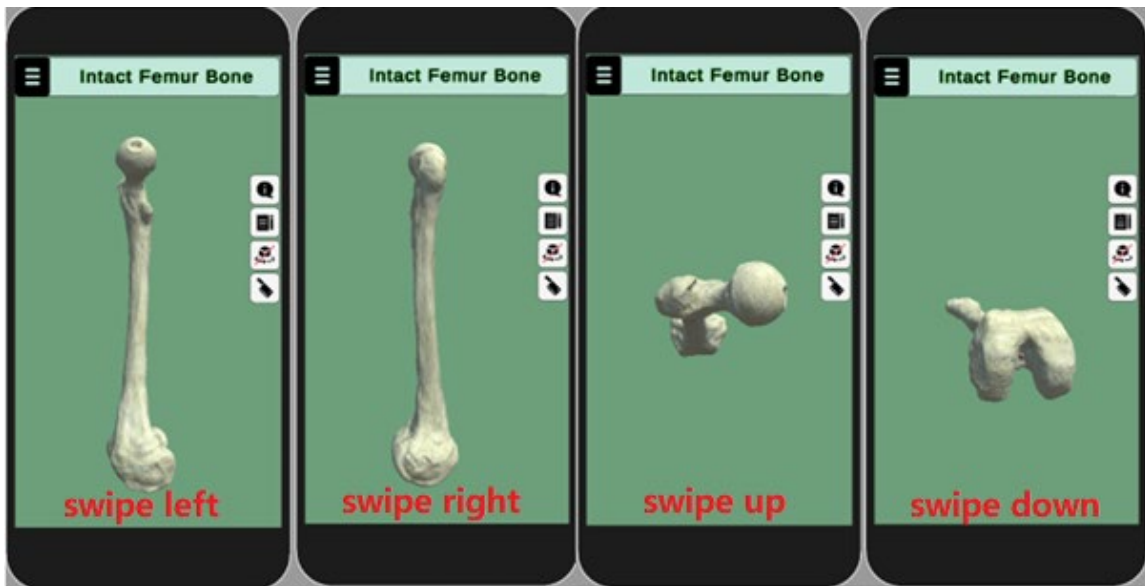


Figure 6.2.2.2-T3(1): Relationship between Swipe Direction and Bone Model Rotation Direction

Table 6.2.2.2-T3(3): Achievability Testing - Bone Rotation

Test time	Status
1	Success
2	Success
3	Success
4	Success
5	Success
6	Success
7	Success
8	Success
9	Success
10	Success

- **Acievability test on bone model cutting**

This test is mainly to test the achievability on cutting the bone model, and its ability to play sound effect if user cut the bone successfully. There is a total of 10-time tests for this feature.

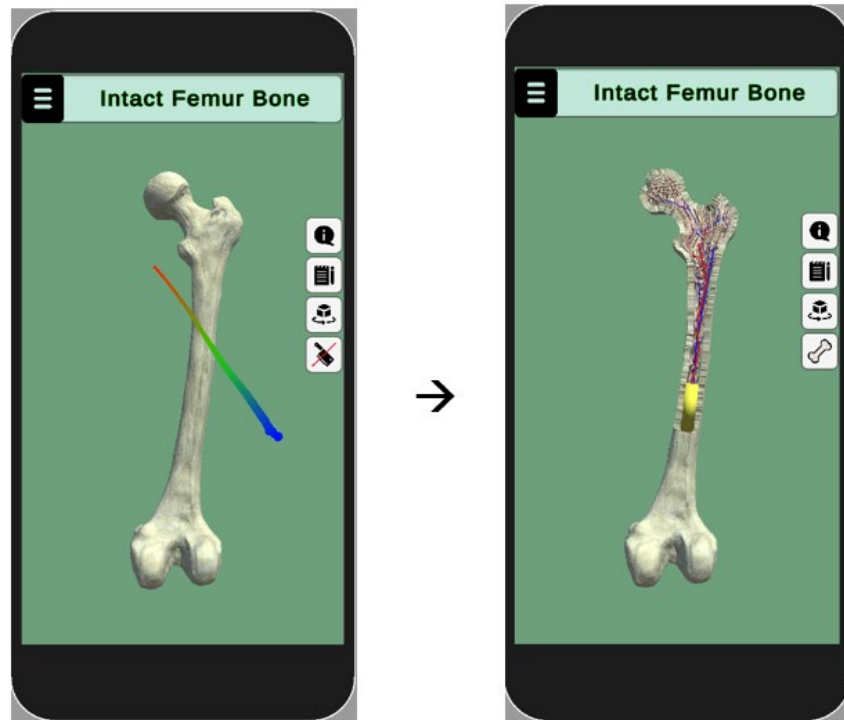


Figure 6.2.2.2-T3(2): Bone Cutting

Table 6.2.2.2-T3(4): Achievability Testing - Bone Cutting

Test time	Status
1	Success
2	Success
3	Success
4	Success
5	Success
6	Success
7	Success
8	Success
9	Success
10	Success

- **Achievability Testing on bone model scaling**

This test is to test the feature working properly if repetitively scaling (either zoom in and zoom out) the bone model. There is a total of 10-time tests for done for this feature.

Bachelor of Information Systems (Honours) Information Systems Engineering
 Faculty of Information and Communication Technology (Kampar Campus), UTAR

Table 6.2.2.2-T3(5): Achievability Testing - Bone Scaling

Test time	Status
1	Success
2	Success
3	Success
4	Success
5	Success
6	Success
7	Success
8	Success
9	Success
10	Success

6.2.2.3 Quiz Module

Test 1: Overall Quiz Process

Table 6.2.2.3-T1: Unit Testing - Quiz

Test Case	Description	Actions	Test Data	Expected Result	Status
1	Check if quiz questions are able to display properly and allow user to select the answer.	<ol style="list-style-type: none"> 1. Click “Start” button. 2. Check all the answers. 3. Uncheck all the answers. 	N/A	The UI should perform perfectly.	Pass

2	Check whether the explanation displayed if users choose the wrong answer.	<ol style="list-style-type: none"> 1. Select a wrong answer for any question. 2. Click “Submit” button. 	The wrong answer	It should display an explanation to user.	Pass
3	Check if the resolution screen display after user answer on each question.	<ol style="list-style-type: none"> 1. Choose any of the answers. 2. Click “Submit” button. 3. Click “Next” button. (if wrong answer chosen) 	Any of the answers	It should display a resolution screen to user along with the status of correctness as well as the current score.	Pass
3	Check if the question is changed properly.	<ol style="list-style-type: none"> 1. Choose any of the answers. 2. Click “Submit” button. 3. Click “Next” button. (if wrong answer is chosen) 	Any of the answers	It should display another question to user after the resolution screen unless there are no other questions.	Pass
4	Check the changes in scores.	<ol style="list-style-type: none"> 1. Choose any of the answers. 2. Click “Submit” button. 	Any of the answers	The score at the top left corner is updated accordingly, as well as the current score in the temporarily resolution screen.	Pass

5	Check if the final result screen is displayed properly.	<ol style="list-style-type: none"> 1. Choose any of the answers. 2. Click “Submit” and “Next” button if wrong answer chosen. 3. Repeat steps 1 and 2 until there are no other questions. 	Any of the answers	The final result screen is displayed properly along with the final score and history highest score. (If current score is the highest score, it should show a “new” word in front of the highest score)	Pass
---	---	---	--------------------	--	------

Test 2: Score Retrieved from Firebase Cloud to Display Leaderboard

```

public void LeaderboardButton()
{
    Debug.Log("Start Time (Load Leaderboard): " + Time.time * 1000);
    StartCoroutine(LoadLeaderboard());
    Debug.Log("Finish Time (Load Leaderboard): " + Time.time * 1000);
}

```

Figure 6.2.2.3-T2(1): Code - Retrieve Score and Display Leaderboard from Firebase Cloud

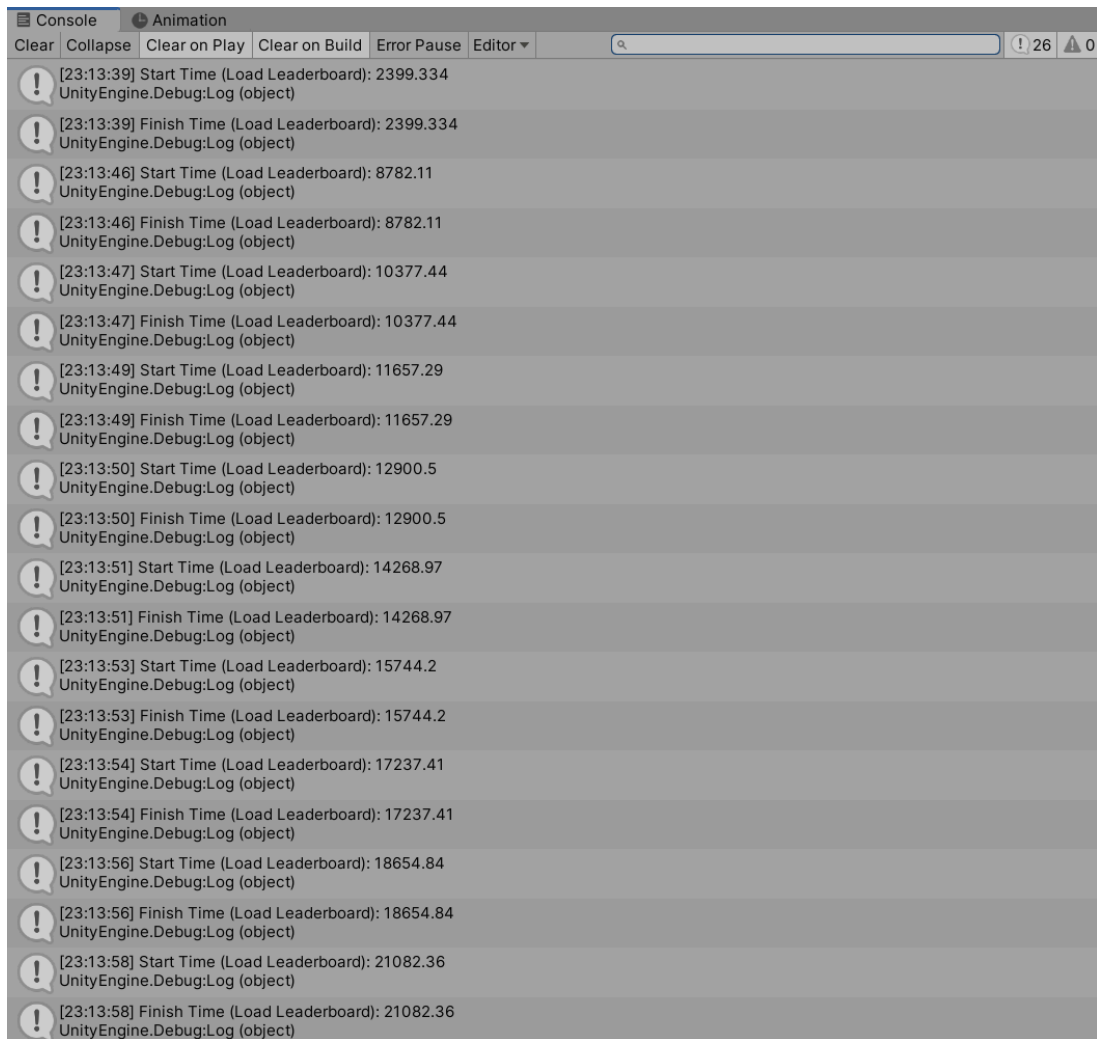


Figure 6.2.2.3-T2(2): Results - Retrieving Score and Displaying Leaderboard

Table 6.2.2.3-T2: Time Testing - Retrieving Score and Displaying Leaderboard

Test time	Start time (in ms)	Finish time (in ms)	Time taken (in ms)
1	2399.334	2399.334	0
2	8782.11	8782.11	0
3	10377.44	10377.44	0
4	11657.29	11657.29	0
5	12900.5	12900.5	0
6	14268.97	14268.97	0
7	15744.2	15744.2	0
8	17237.41	17237.41	0
9	18654.84	18654.84	0

10	21082.36	21082.36	0
Average			0

6.2.2.4 Learning Module

Test 1: Video Playing

There are 2 types of tests included in this module, which are unit testing and Achievability Testing. The intention of using unit testing in this module is to test the video playing ability, while the Achievability Testing is to test if the video would continue playing if clicking on the “fullscreen” and “minscreen” buttons repeatedly, as well as for the “start” and “pause” button.

- **Unit Testing**

Table 6.2.2.4-T1(1): Unit Testing – Video Playing

Test Case	Description	Actions	Test Data	Expected Result	Status
1	Check if video can be played with sound.	1. Click “Play” button.	N/A	The video should be able to play with sound.	Pass
2	Check if video can be play in fullscreen mode.	1. Click “Play” button. 2. Click “fullscreen” button. Note: Step 1 and 2 can be done interchangeably.	N/A	The video should be able to play in fullscreen mode.	Pass
3	Check if video can be continue playing after pausing.	1. Click “Play” button. 2. Click “Pause” button.	N/A	The video should be able to continue playing after pausing.	Pass

		3. Repeat step 1 and 2.			
4	Check if video can be continue playing on previous state after clicking to another tab.	1. Click “Play” button. 2. Click another tab of video list. 3. Click back to previous tab of video list.	N/A	The video should be able to continue playing from previous state.	Fail

- **Achievability Testing**

Table 6.2.2.4-T1(2): Achievability Testing - Video Playing (Fullscreen & Minscreen)

Test time	Status
1	Success
2	Success
3	Success
4	Success
5	Success
6	Success
7	Success
8	Success
9	Success
10	Success

Table 6.2.2.4-T1(3): Achievability Testing - Video Playing (Start & Pause)

Test time	Status
1	Success
2	Success
3	Success
4	Success

5	Success
6	Success
7	Success
8	Success
9	Success
10	Success

Test 2: General Information

There is only text and images to be displayed in this module, hence the test cases for this module are only to ensure the information can be displayed perfectly in both the portrait and landscape mode.

Table 6.2.2.4-T2: Unit Testing – General Information

Test Case	Description	Actions	Test Data	Expected Result	Status
1	Check if the information can be display perfectly in portrait mode .	1. Remain portrait mode of the mobile device or simulator.	N/A	The information of text and images should be displayed perfectly and no overlapping.	Pass
2	Check if the information can be displayed perfectly in landscape mode .	1. Rotate the mobile device or simulator to landscape mode.	N/A	The information of text and images should be displayed perfectly and no overlapping.	Pass

6.2.2.5 Offline Testing

Since this system is developed for both online and offline usage, this testing is inevitable and is essential to ensure the data is consistent and minimise the risk of encountering the issue of data loss. There are few steps taken to conduct this test:

1. Log in to the Firebase Cloud and get the current data.
2. Disconnect the internet.
3. Modify and save data in the simulator.
4. Connect back to the internet.
5. Observe the change in Firebase Cloud.

Figure 6.2.2.5-1 shows the data that have stored in Firebase Cloud, Figure 6.2.2.5-2 shows the data have been modified without the internet, Figure 6.2.2.5-3 shows the changes in Firebase Cloud after re-connect back to the internet.

To achieve this, it is actually through comparing the timestamps.

In conclusion, this offline testing has passed.

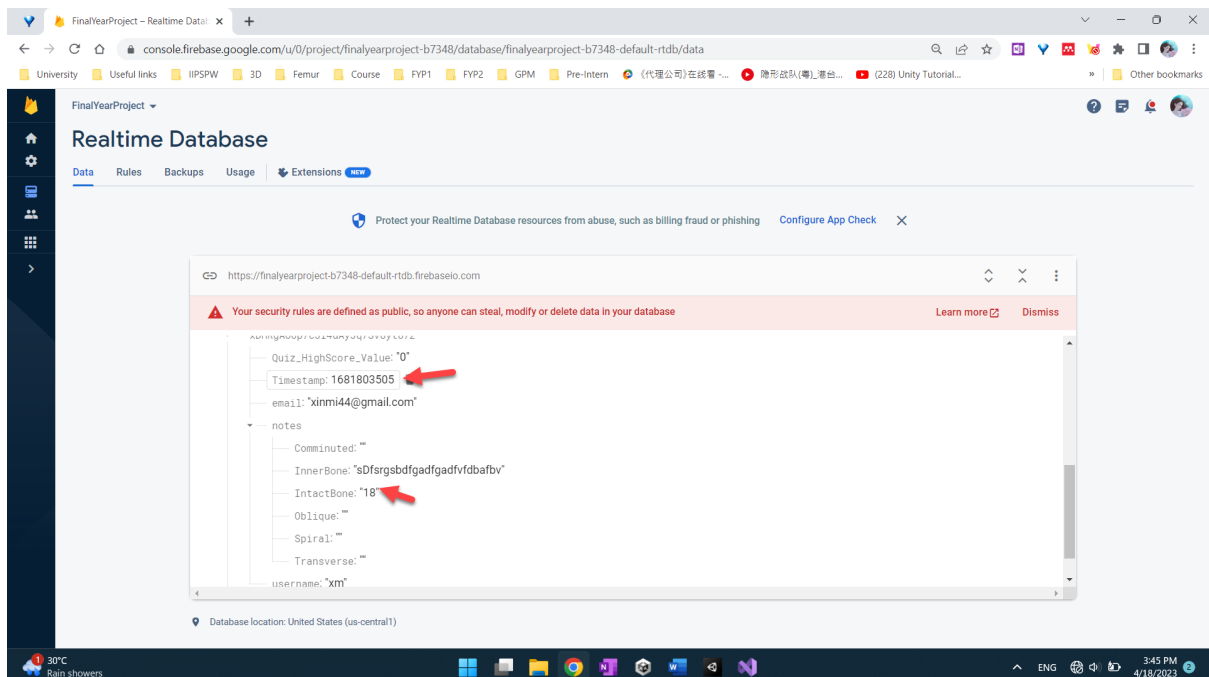


Figure 6.2.2.5-1: Offline Test - Data Saved Previously in the Cloud

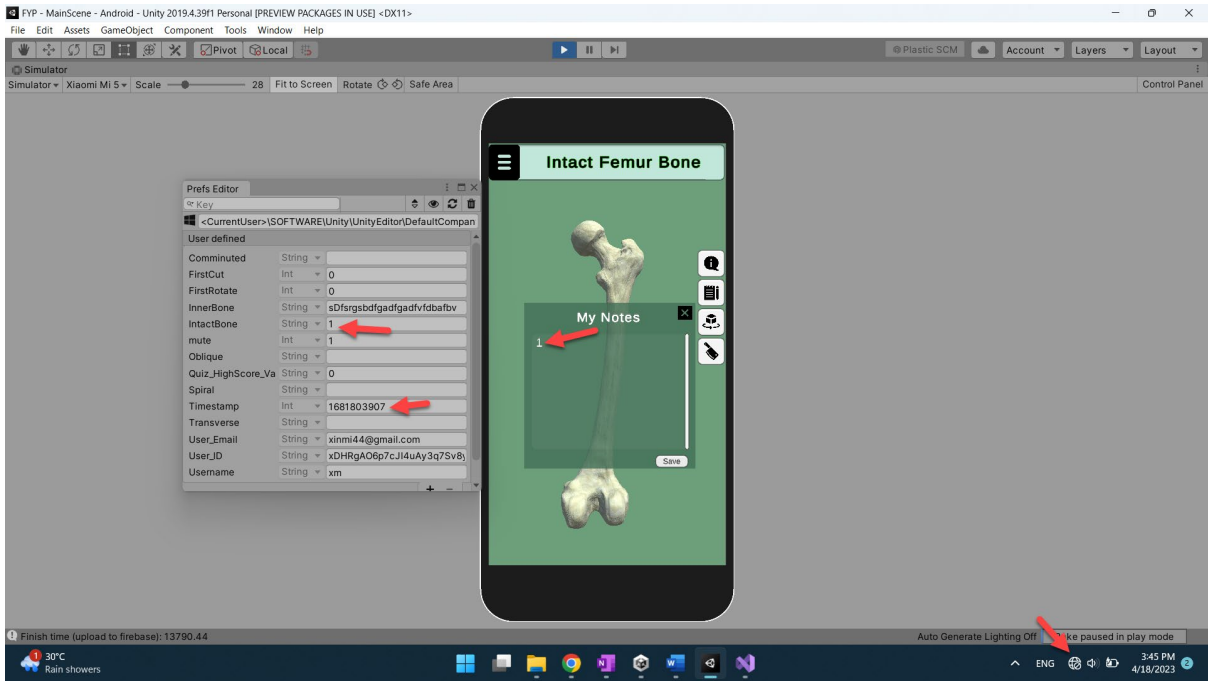


Figure 6.2.2.5-2: Offline Test - Data Modified without the Internet

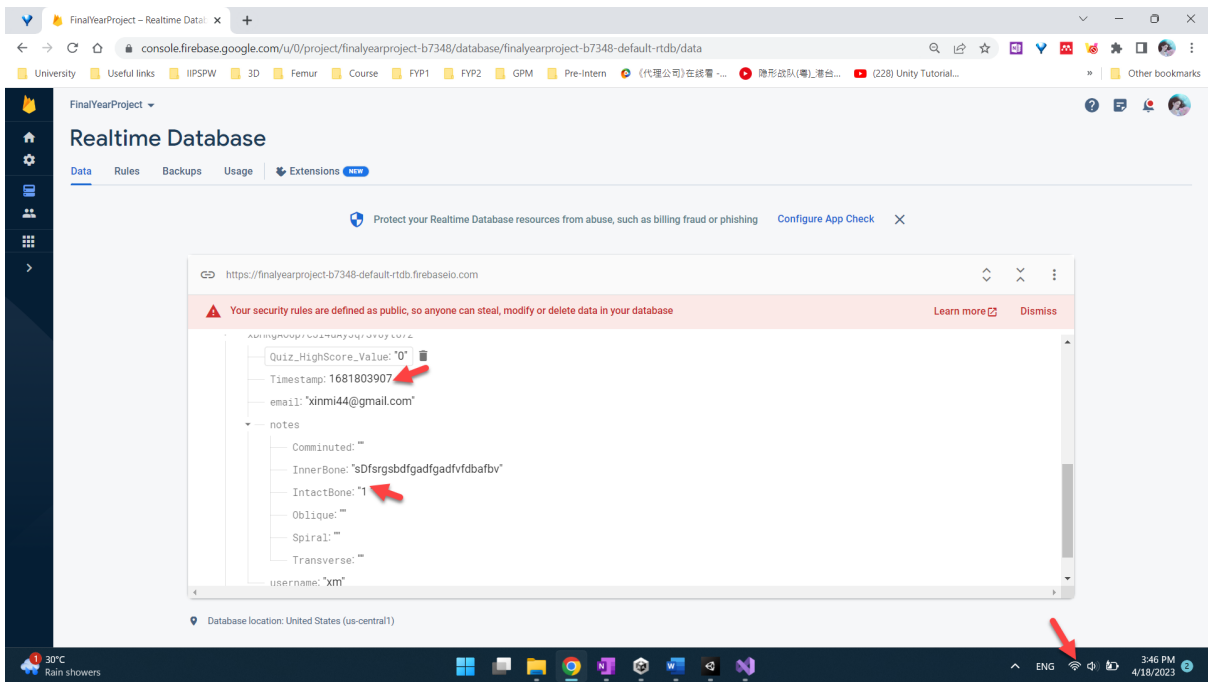


Figure 6.2.2.5-3: Offline Test – Data Updated with the Internet

6.2.2.6 Background Music

Table 6.2.2.6-T1: Unit Testing – Background Music

Test Case	Description	Actions	Test Data	Expected Result	Status
1	Check if the background music is played normally when first start the app.	1. Run the app.	N/A	The background music should be able to play.	Pass
2	Check if the background music status if playing video.	1. Play a video.	N/A	The background music should be muted automatically.	Pass
3	Check if the background music status if click on the “Mute” button.	1. Click “Main Menu” button. 2. Click “Mute” button.	N/A	The background music should be muted.	Pass
4	Check if the background music status if click on the “Sound” button.	1. Click “Main Menu” button. 2. Click “Sound” button.	N/A	The background music should be able to play normally again.	Pass
5	Check if background music status on restarting the app after	1. Click “Mute” button. 2. Close the app. 3. Run the app again.	N/A	The background music should be muted by default.	Pass

	clicking “Mute” button.				
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6.2.2.7 Survey Testing Result

There are a total of 9 questions designed for this testing, and there are 15 individuals participating in it. Since the target users of this project are not medical professionals, none of the respondents had a medical background.

Do you found it easy to use this application?
15 responses

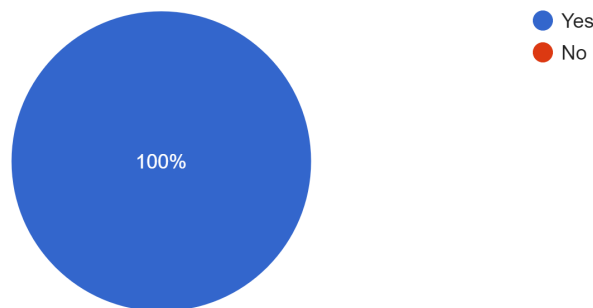


Figure 6.2.2.7-1: Survey Testing - Q1

As in Figure 6.2.2.7-1, all the respondents agree that the application is easy to use, which can be attributed to the navigational design of the application, which makes it possible for users to use the feature quickly at a glance. This is the most basic but extremely important for developing a mobile application as it will directly affect the user experience if the design of navigation is difficult to understand.

Do you think this application is easy for you to learn about the human femur and its potential shaft fractures?

15 responses

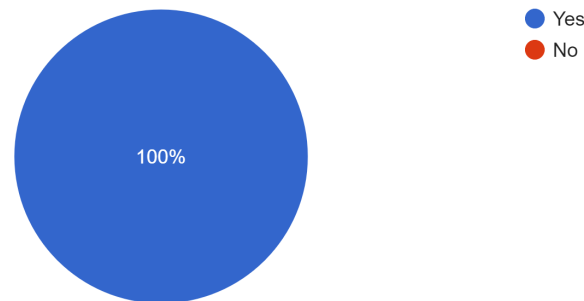


Figure 6.2.2.7-2: Survey Testing – Q2

Aligning with the project title, there is a question about the ease of learning on human femur and its potential shaft fractures. This is considered an important concern as people are always trying to look for the easiest and fastest way to acquire new knowledge. As shown in Figure 6.2.2.7-2, all the respondents agree that this mobile application makes it easy to learn about the human femur and its potential shaft fracture.

Do you found the information involved in this application is adequate?

15 responses

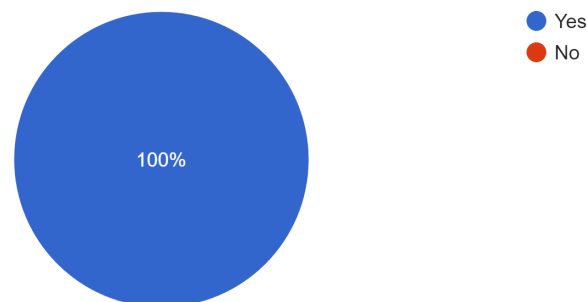


Figure 6.2.2.7-3: Survey Testing – Q3

It is important that the information is adequate for an educational mobile application, hence this question is designed. As Figure 6.2.2.7-3 illustrated, from the small group of respondents

who were without the medical background, they found that the information is adequate for them to learn about the human femur and its potential shaft fracture.

Do you think this application can easily retrieve and backup your data from and to the cloud?

15 responses

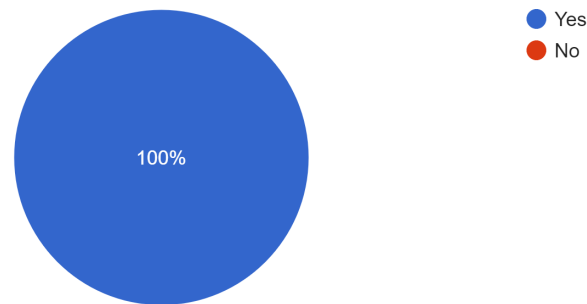


Figure 6.2.2.7-4: Survey Testing – Q4

Since this application is designed to allow users to use it across different devices, storing data in the cloud is needed, and therefore, this question is designed. Figure 6.2.2.7-4 shows that all the respondents feel that this application allows them to retrieve and backup data in an easy way.

Do you found interesting while using this application?

15 responses

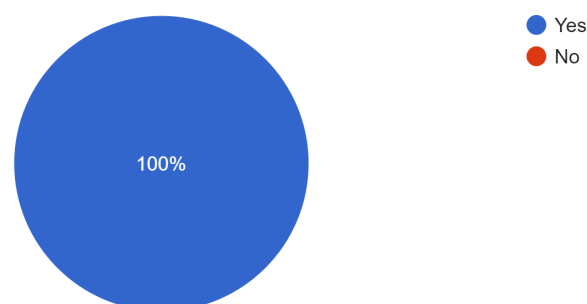


Figure 6.2.2.7-5: Survey Testing – Q5

Figure 6.2.2.7-5 indicates that all the respondents are interested in using the application to learn human femur and its potential shaft fractures.

Which feature you like the most when using this application?

15 responses

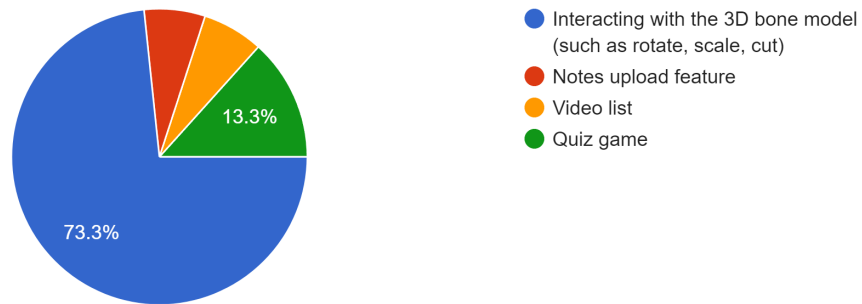


Figure 6.2.2.7-6: Survey Testing – Q6

As the pie chart in Figure 6.2.2.7-6 shown, 73.3% of respondents like the feature of interacting with the bone models, 13.3% of the respondents like the quiz game, and others (13.4%) like the feature of notes and video lists. This can be concluded that most of the respondents prefer the interaction with the bone models, maybe because 3D models can provide an immersive visualisation and bring new experience for them to learn about the human femur.

How you would rate the user interface (UI) for this application?

15 responses

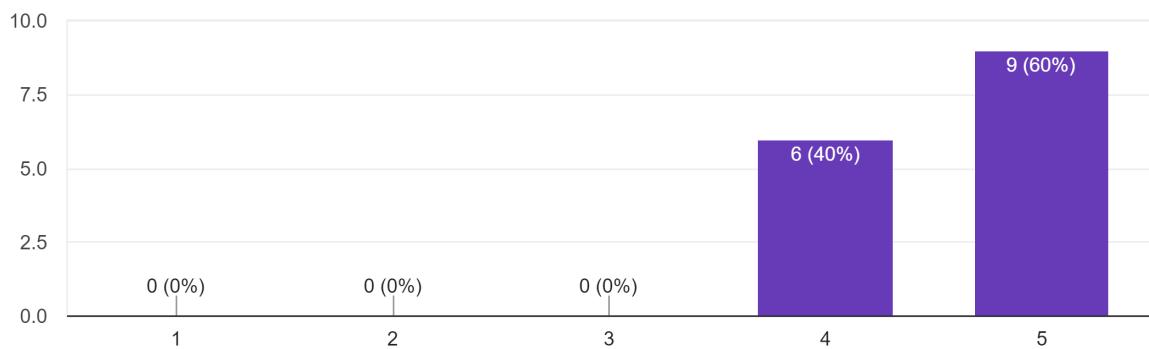


Figure 6.2.2.7-7: Survey Testing – Q7

As in Figure 6.2.2.7-7, almost all the respondents are satisfied on the user interface of this application.

How you would rate the overall performance of this application?

15 responses

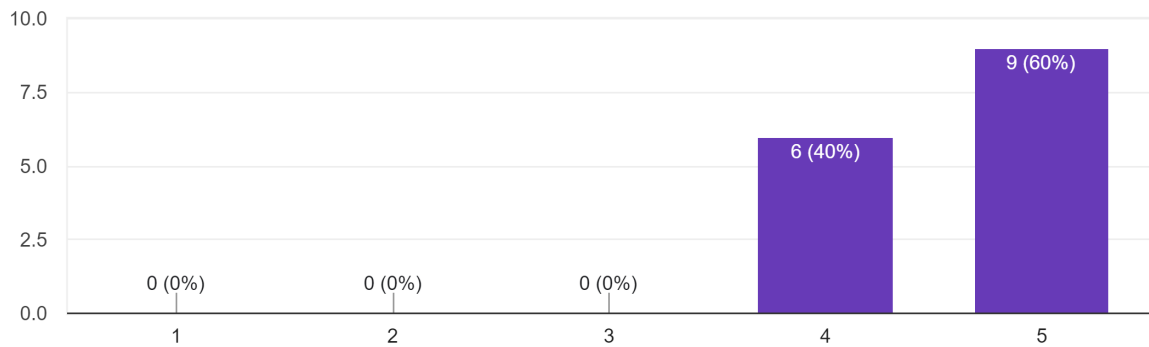


Figure 6.2.2.7-8: Survey Testing – Q8

The overall performance is also satisfied by most of the respondents. Hence, this is considered a good start for the development of this application.

Any other improvement(s) do you think can still be implemented for this application?

15 responses

The image shows a list of 15 survey responses for question Q9. The responses are displayed in a vertical list of light gray boxes, each containing a user's answer. The responses are: 'no', 'more bone', 'It can be considered as a good application in this rare area. Still can include more features.', 'no bug', 'maybe can try to make the quiz game more interesting with various set of questions', 'consider to make the notes feature more useful, such as allow users to make stylish notes', 'more interaction options to the bone', 'include more reference materials', 'try to enhance the video playing feature', 'the video list idea is good, but lack of control', 'Overall is good, I like the ranking feature for the quiz game that can motivate me to learn more!', 'include some real cases maybe?', 'I like the way of labeling, but still can be improved', and 'No'.

no
more bone
It can be considered as a good application in this rare area. Still can include more features.
no bug
maybe can try to make the quiz game more interesting with various set of questions
consider to make the notes feature more useful, such as allow users to make stylish notes
more interaction options to the bone
include more reference materials
try to enhance the video playing feature
the video list idea is good, but lack of control
Overall is good, I like the ranking feature for the quiz game that can motivate me to learn more!
include some real cases maybe?
I like the way of labeling, but still can be improved
No

Figure 6.2.2.7-9: Survey Testing – Q9

There are some invaluable feedbacks got from respondents throughout the entire survey. Some of them have provided useful insight into prospective directions to elevate the application to a greater height. For instance, suggestions on adding more bone and more interaction options to the bone, which can lead to a better experience for users to learn human femur. Besides, adding additional resources to supplement the 3D visualisation by including more reference materials or some real cases can raise interest of users to explore more on the human femur. There are also some respondents request to enhance the video list and notes features.

6.3 Objectives Evaluation

Objective 1: To develop an informative educational mobile application for users to gain knowledge of the human femur in detail so that they can master the anatomy of the human femur easily. (Achieved, but some features may not efficient enough)

Aligned with the project title, the mobile application has been created solely based on the human femur, and mainly focuses on human femoral shaft fractures. There is labelling designed for different structures of the 3D human femur bone model along with highlight colour. Not only the outer part but also the inner part of the bone model has been created and imported to the mobile application. Besides, there is additional information, such as some facts, risk factors, general approximate healing time, possible treatments, complications, and different classifications for human femoral shaft fractures where users can always check on that. While putting focus back to the femoral shaft fractures, there are 4 most common types of femoral shaft fractures have also been created and imported into this mobile application, which allowing users to have a better sight on the different types of fractures. Furthermore, there are 3 categories of video lists included in this mobile application, which assist users to have a more understanding of human femur and its potential shaft fractures. However, the feature of video lists developed is inadequate because there is no scrub control and is not able to continue playing from the previous state after clicking to another tab of video lists. Video lists with scrub control can be a complex task as it not only requires knowledge of mobile app development but also the knowledge of video codec. To sum up, this objective is considered achieved, but not efficient.

Objective 2: To develop a better learning experience for users to learn the anatomy of the human femur and its potential shaft fractures. (Achieved, but some features may not efficient enough)

A mobile application is able to enhance the overall learning experience thanks to its easy portability, which allows users to continue their learning anywhere and anytime. Besides, as stated in the previous objective, there are different 3D bone models that have been included in this mobile application which can provide a way to visualise and interact with those complex anatomical structures in a more intuitive and immersive way. The interaction features developed in this mobile application involve rotation, scaling, and cutting. Moreover, this

mobile application is developed along with a note feature, which allows users to save their notes for further revision. Even if the notes feature is inadequate, as it only supports saving text as notes, it can still serve as a short note for users to record their brief notes while learning without using paper or books. The reason that the notes feature is not able to achieve in a more efficient way is that it is a complex task, and also require a deep understanding of the “TextMeshPro” component, maybe also along with some plug-in from Unity that I am currently consisting of not enough time to deal with it. Furthermore, as previously stated, this mobile application is developed to support both online and offline. Again, it benefits users to learn without the internet, which supports the statement that users can continue learning at any time. Also, users can no longer worry about data loss due to network issues, an example is the notes being saved abnormally. The offline testing part also proves that, upon reconnecting to the internet, all locally saved data would be instantly updated in the cloud. Lastly, there is a simple quiz game developed along with a leaderboard to increase the interest of users in continuing to use this mobile application. Other than testing users’ current knowledge levels, the leaderboard, which also acts as a ranking, might motivate users to continue their study so they can achieve a better score for the quiz at the next attempt. This ultimately creates a better learning experience and improves the interest of users in using this mobile application, and the objective is also considered achieved.

Objective 3: To develop a completely free educational mobile application devoid of any advertisements so that lessen user strain from having to purchase pricey software or real bone which might be hard to come by. (Achieved)

Based on previous research and reviews, most of the applications are costly to use, which results in a burden on users who really need the application for learning purposes. Besides, some of them consist of advertisements while using them, which can directly affect the user experience. Hence, this application is ultimately developed, requires zero cost to use and devoid of any advertisements.

6.4 Concluding Remark

This chapter is mainly focused on the testing and evaluation of the entire developed system. By observing the results and objectives evaluation, this project has passed most of the tests and achieved all the objectives.

Chapter 7

Conclusion and Recommendation

7.1 Conclusion

Throughout the entire development process, there are a lot of issues and challenges that have been encountered, such as extra time needed to learn the new tools that are required to develop this project. The tools include Unity, Blender, and Firebase realtime database. For instance, to deal with the data synchronisation feature in this project, it is necessary to have a prior understanding of the framework of the Firebase realtime database. Besides, 3D is another new learning area that I have not explored previously. It is a complex topic to learn within a short period because it requires numerous technical skills and software knowledge in order to produce a high-quality 3D model, and it covers a lot of topics too, such as geometry, lighting, texturing, and rendering.

Additionally, when trying to create a mobile application using Unity, there are a lot of issues that I have encountered, the most common issue is regarding the user interface. It is sometimes difficult and trouble to deal with due to a lack of understanding of the component structure and its order. Moreover, since Unity is a powerful and feature-rich game engine, which also means that it has a steep learning curve, and sometimes the features can be difficult to learn and master. For instance, the “TextMeshPro” component is not simply for displaying text, but it also consists of several features, such as rich-text, dynamic text sizing, text styling, and others. It also has the ability to create high-quality and stylish text by applying textures. Because there is so much to learn from just one component, it is understandable that mastering Unity to create a solid mobile application can be challenging.

Other than the tools, human femur is another new topic that I should learn while developing this project. This is because I am not a biology student and have not even taken biology subjects previously. The femur is a complex bone, and understanding its anatomy and structure requires knowledge of medical terminology and concepts that may be unfamiliar. It can also be difficult for me to learn about potential shaft fractures because it requires an understanding of the forces that can cause the fracture, such as traumatic injuries or underlying medical conditions.

Additionally, the treatment and management of femur fractures may require knowledge of surgical procedures, medical devices, and rehabilitation techniques that are outside my expertise. Hence, learning about the human femur and its potential shaft fracture requires a strong foundation in anatomy, physiology, and medical terminology, which can be challenging for me as a non-biology student.

In conclusion, this project has ultimately come up with a mobile application for users to learn about the human femur and its potential shaft fractures. The application offers interactive and immersive visualisations of the femur bone, common types of fractures, and their corresponding treatment options. Besides, the application is designed to be user-friendly and accessible to everyone, providing a comprehensive and engaging educational resource. The main modules involved in this application include bone module, quiz module, profile module, and learning module. It was tested and evaluated by a group of users without a medical background, who provided valuable feedback to enhance the user experience. Overall, this project provides a novel approach to the educational field and has the potential to increase the awareness of femoral shaft fractures among non-medical professionals, promoting a better understanding of human anatomy and injuries.

7.2 Recommendation

Nothing is perfect, everything still can be improved, and there is no exception for this project. There is still a lot of space for this project to improve. According to the feedback from the survey, there are some valuable suggestions that have been mentioned. All the suggestions will be taken into consideration in order to enhance the overall quality of the system. For instance, including more bone and interaction options for the bones allow making it a more interesting way for users to learn about the human femur, and including more reference materials or some real cases could make the application a more comprehensive learning tool. Then, making the video to be controllable is always an ideal way because it makes it easy for users to watch the video. The notes feature can also be enhanced to allow users to design their special notes for easy revision, such as allowing highlighting and bold text, maybe allowing them to add images and drawing also if possible. Besides, there is one of the features that mentioned in previous chapter has not been done, which is allow highlighting any part of the bone structure. This can

also be the future work of this project. Lastly, including a different set of quiz questions is also essential to test the users' knowledge thoroughly. I believe this can improve the overall user experience if all the mentioned recommendations have been done and achieved.

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APPENDIX

FYP Survey: A 3D Educational Mobile Application for Femoral Shaft Fractures

Thank you for taking the time to provide feedback on my Final Year Project (FYP) "3D Educational Mobile Application for Femoral Shaft Fractures". Your responses will be used to evaluate the effectiveness and usability of the application, identify areas that may need improvement, and ultimately enhance the overall user experience. I appreciate your input and value your opinion. Please take a few minutes to complete the following survey.

Do you found it easy to use this application? *

- Yes
- No

Do you think this application is easy for you to learn about the human femur and its potential shaft fractures? *

- Yes
- No

Do you found the information involved in this application is adequate? *

- Yes
- No

Do you think this application can easily retrieve and backup your data from and to the cloud? *

- Yes
- No

Do you found interesting while using this application? *

- Yes
- No

Which feature you like the most when using this application? *

- Interacting with the 3D bone model (such as rotate, scale, cut)
- Notes upload feature
- Video list
- Quiz game

How you would rate the user interface (UI) for this application? *

- | | | | | |
|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| 1 | 2 | 3 | 4 | 5 |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

How you would rate the overall performance of this application? *

- | | | | | |
|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| 1 | 2 | 3 | 4 | 5 |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Any other improvement(s) do you think can still be implemented for this application? *

Long answer text

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	Study week no.: 2
Student Name & ID: Lam Xin Mi (19ACB02794)	
Supervisor: Ts Saw Seow Hui	
Project Title: A 3D Educational Mobile Application for Femoral Shaft Fractures	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Modify the overall UI and some of the structure of Unity project.
- Complete user login and register module.
- Complete notes module.
- Review technologies might be involved in this project (report chapter 2) and add additional information to background (report chapter 1).

2. WORK TO BE DONE

- Learn modeling skills on breaking the bone.
- Labeling the bone structure.
- Look for more information about bone fractures.

3. PROBLEMS ENCOUNTERED

- The size of notes and information panel remains immutable, maybe there is an issue on the code that has not been figured out.
- 3D models can only rotate from the middle, because of using the cube collision and tag.
- Video unable to play on full screen.

4. SELF EVALUATION OF THE PROGRESS

To prevent the FYP progress fall behind schedule at the beginning of the new trimester start (because of being busy seeking internship companies, interviews, catch up on the progress in the class of another subject), I try to do more during my semester break. The overall progress is considered smooth, and I have completed the login and register module, as well as the note backup module.



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	Study week no.: 4
Student Name & ID: Lam Xin Mi (19ACB02794)	
Supervisor: Ts Saw Seow Hui	
Project Title: A 3D Educational Mobile Application for Femoral Shaft Fractures	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Complete chapter 3 of the report and modify chapter 4 (add activity diagrams for login and register module, as well as note backup module).
- Start learning some modeling skills through YouTube.
- Reorganize and plan tasks of the project according to priority.

2. WORK TO BE DONE

- Cut intact bone into different parts/structure for later labeling.
- Solve notes and information panel resize issue.
- Solve video unable to play in full screen issue.
- Design the label for showing information or name of the particular bone part.

3. PROBLEMS ENCOUNTERED

- No critical issue found.

4. SELF EVALUATION OF THE PROGRESS

Even if busy completing assignment and preparing documents for applying internship job, I still try my best to work on some part of the report and learn some modeling skills. Besides, to ensure myself is always clear on what to do for the project, I made a plan, list down all the current FYP small tasks, and reorganize them for easy referring and working on it.



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	Study week no.: 6
Student Name & ID: Lam Xin Mi (19ACB02794)	
Supervisor: Ts Saw Seow Hui	
Project Title: A 3D Educational Mobile Application for Femoral Shaft Fractures	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Complete chapter 2 of the report.
- Cut the intact femur bone model into different parts.
- Add tag to each of the parts and apply colour on clicked part of a particular bone structure.

2. WORK TO BE DONE

- Design the label for showing information or name of the particular bone part.
- Solve notes and information panel resize issue.
- Solve video unable to play in full screen issue.
- Cut and model for the inner part of femur bone.

3. PROBLEMS ENCOUNTERED

- No critical issues found.

4. SELF EVALUATION OF THE PROGRESS

Although there are a lot of job interview sessions ongoing, I try to deal with a little of the report and cutting the intact bone model into different parts for labeling. The progress maybe slow since week 4, but overall progress in considered on the track.



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	Study week no.: 8
Student Name & ID: Lam Xin Mi (19ACB02794)	
Supervisor: Ts Saw Seow Hui	
Project Title: A 3D Educational Mobile Application for Femoral Shaft Fractures	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Complete modeling inner part of the femur bone. imported into Unity and added tag for each of the parts.
- Draft designing the labeling for showing the bone structure naming.
- Fix model rotation issue by only activating rotation feature after clicking on a button.
- Rearrange part of the report.
- Fix slider menu bug by adding additional vertical layout group.
- Fix information content resize.

2. WORK TO BE DONE

- Solve video unable to play in full screen issue.
- Add feature on allowing user to cut the bone.
- Add more information regarding the bone fractures.
- Add more quiz questions.

3. PROBLEMS ENCOUNTERED

- Output of inner bone texture exported anomaly, result show different in Blender and Unity.

4. SELF EVALUATION OF THE PROGRESS

Everything was considered to progress smoothly. Time allocated effectively to complete desired tasks within 2 weeks. However, still have to work harder to get all tasks completed with the least bugs.



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	Study week no.: 10
Student Name & ID: Lam Xin Mi (19ACB02794)	
Supervisor: Ts Saw Seow Hui	
Project Title: A 3D Educational Mobile Application for Femoral Shaft Fractures	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Done adding cut feature.
- Modify the button by only allowing user to click on either rotate or cut button at once but not both.

2. WORK TO BE DONE

- Solve video unable to play in full screen issue.
- Add more information regarding the bone fractures.
- Add more quiz questions.
- Complete full report with poster.

3. PROBLEMS ENCOUNTERED

- No critical issue found.

4. SELF EVALUATION OF THE PROGRESS



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	Study week no.: 12
Student Name & ID: Lam Xin Mi (19ACB02794)	
Supervisor: Ts Saw Seow Hui	
Project Title: A 3D Educational Mobile Application for Femoral Shaft Fractures	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Complete the feature for enabling fullscreen video playing.
- Complete overall system functions.
- Repeat testing and fixing bugs.
- Complete report with poster.

2. WORK TO BE DONE

3. PROBLEMS ENCOUNTERED

- No critical issue found.

4. SELF EVALUATION OF THE PROGRESS

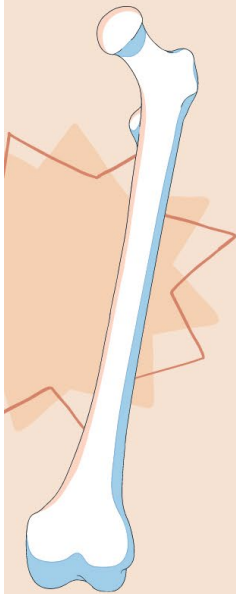


Supervisor's signature



Student's signature

A 3D EDUCATIONAL MOBILE APPLICATION FOR FEMORAL SHAFT FRACTURES



INTRODUCTION

This project is mainly to develop a mobile application for normal users without any medical background but who are interested in learning about different types of human femoral shaft fractures from a 3D perspective.

OBJECTIVE

- 1 To develop an informative educational mobile application for users to gain knowledge of the human femur in detail so that they can master the anatomy of the human femur easily.
- 2 To develop a better learning experience for users to learn the anatomy of the human femur and its potential shaft fractures.
- 3 To develop a completely free educational mobile application devoid of any advertisements so that lessen user strain from having to purchase pricey software or real bone which might be hard to come by.

PROPOSED METHOD

- 1 The intact bone and most common types of human femoral shaft fractures will be included along with note function
 - The 4 types of fractured bones present as the 3D model for a better visualisation
 - For easy jotting notes
- 2 Related videos, text information, and reference links will also be included
 - For deepening understanding
- 3 Quiz game included along with a leaderboard
 - Allow knowledge testing and motivate learning

WHY PROPOSED SYSTEM IN THIS PROJECT IS WORKABLE?

There is no individual platform for learning human femoral shaft fracture. This project is trying to centralise and gather all the related human femoral shaft fracture information to develop this application.

CONCLUSION

A simple and usable 3D platform for human femoral shaft fractures allows learners who have no medical background to have a better understanding and view so as to increase their awareness of potential femoral shaft fractures and promote a better understanding of human femur injuries.

Project Developer: Lam Xin Mi

Project Supervisor: Ts Saw Seow Hui

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STUDENT PAPERS

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Publication | <1 % |
| 2 | "Clinical Classification in Orthopaedics Trauma", Springer Science and Business Media LLC, 2018
Publication | <1 % |
| 3 | R. Ramesh Kumar, D. Rajesh, S. Kumaran, S. Ranjieth, Mohammed Irshad Ali, K. Karthik. "Investigation on tensile characteristics of femur bone 3D model by using FDM", Materials Today: Proceedings, 2021
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| 4 | Bone and Joint Injuries, 2014.
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| 5 | J. Bruce Ralphin Rose. "Computational and experimental investigation on the effect of failure stress in a femur bone", Journal of | <1 % |
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Bertrand Vedrine, Fabien Gérard. "Veterinary Cuttable Plate in a Plate-Rod Construct for Repair of Diaphyseal Femoral Fractures in the Cat", Veterinary and Comparative Orthopaedics and Traumatology, 2018

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ID Number(s)	19ACB02794
Programme / Course	BACHELOR OF INFORMATION SYSTEMS (HONOURS) INFORMATION SYSTEMS ENGINEERING
Title of Final Year Project	A 3D EDUCATIONAL MOBILE APPLICATION FOR FEMORAL SHAFT FRACTURES

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Note Supervisor/Candidate(s) is/are required to provide softcopy of full set of the originality report to Faculty/Institute

Based on the above results, I hereby declare that I am satisfied with the originality of the Final Year Project Report submitted by my student(s) as named above.

Signature of Supervisor

Name: Ts. SAW SEOW HUI

Date: 23/4/2023

Signature of Co-Supervisor

Name: _____

Date: _____



UNIVERSITI TUNKU ABDUL RAHMAN

**FACULTY OF INFORMATION & COMMUNICATION TECHNOLOGY
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I, the author, have checked and confirmed all the items listed in the table are included in my report.

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